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ABSTRACT

The document presents lessons for teaching about occupations related to environmental control, stationary engineering, and refrigeration. Intended for use with the assignments in the related science manual for students, each unit provides the teacher with objectives, a list of aids needed, procedures, a summary, and testing questions. There are 18 available units from which to choose and each lesson involves concrete trade experience where science is applied. Unit titles are: safety and housekeeping, applied physics, basic hand tools, heating systems, stationary engineering and heating equipment, boiler room systems, combustion, combustion equipment, refrigeration, refrigeration equipment, cooling towers and points, ventilating systems and accessories, air conditioning, basic electricity, instruments, operation, and service and maintenance. (LJ)

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State of New Jersey
Department of Education
Division of Vocational Education

STATIONARY ENGINEERING

ENVIRONMENTAL CONTROL

REFRIGERATION

SCIENCE 1 - TEACHERS GUIDE

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CE 005 763

State of New Jersey
Department of Education
Division of Vocational Education

STATIONARY ENGINEERING
ENVIRONMENTAL CONTROL
REFRIGERATION

SCIENCE I - Teachers Guide

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Table of Contents

Page

Unit I - Introduction i

A-1 Introduction to Stationary Engineering 1
B-1 Introduction to Environmental Control 2
C-1 Introduction to Refrigeration 3

Unit II - Safety and Housekeeping

A-1 No Related Science
A-2 Fire Prevention and Housekeeping 4

Unit III - Applied Physics

A-1 Pressure 5
A-2 Pressure-Force-Area Relationship 6
A-3 Measurement of Pressure 7
A-4 Pressure Conversion Factors 8

B-1 Work 9
B-2 Force and Distance Applied to Work 10

C-1 Power 11
C-2 Horsepower 12

D-1 Energy 13

E-1 Basic Theory of Heat 14
E-2 Measurement of Heat 15
E-3 Temperature Conversion 16
E-4 Transmission of Heat 17
E-5 Mechanical Equivalent of Heat 18
E-6 Mechanical Equivalent Conversions 19

F-1 Charles' Gas Laws 20
F-2 Solving Pressure Problems 21

G-1 Boyle's Law 22
G-2 Solving Pressure Volume Problems 23

H-1 General Gas Law 24
H-2 Solving Pressure-Temperature-Volume Problems 25

I-1 Saturated and Superheated Vapors 26

Unit IV - Basic Hand Tools

A-1 Basic Hand Tools (No Related Science)

Unit V - Heating Systems

Page

A-1 Basic Steam Heating System 27
A-2 Basic Pressure and Vacuum Heating Systems 28

B-1 Basic Hot Water Heating System 29
B-2 Natural Circulation Hot Water System 30
B-3 Forced Circulation Hot Water System 31

C-1 Basic Warm Air Heating System 32
C-2 Natural Circulation Warm Air Heating System 33
C-3 Forced Circulation Warm Air Heating System 34

Unit VI - Stationary Engineering and Heating Equipment

A-1 Firetube Boilers 35
A-2 Watertube Boilers 36
A-3 Cast-Iron Sectional Boilers 37

B-1 Steam Boiler Trim 38
B-2 Hot Water Boiler Trim 39

C-1 Steam Accessories 40
C-2 Hot Water Accessories 41
C-3 Warm Air Accessories 42

D-1 Reciprocating Pumps 43
D-2 Use of Force in Reciprocating Pumps 45
D-3 Centrifugal Pump 46
D-4 Rotary and Vacuum Pumps 47

Unit VII - Boiler Room Systems

A-1 Feed-Water System, High Pressure 48
A-2 Feed-Water System, Low Pressure 49

B-1 Basic Fuel Oil System 50
B-2 Fuel Oil Consumption 51

C-1 Draft and Its Measurement 52
C-2 Natural and Mechanical Draft 53

Unit VIII - Combustion

A-1 Combustion Chemistry 54

B-1 Types of Combustion 55

C-1 Process of Combustion 56
C-2 Theoretical Combustion Air Requirements 57

Unit IX - Combustion Equipment

Page

A-1 Mechanical Atomizing Burner 58
A-2 Air Atomizing Burner 59
A-3 Rotary Cup Oil Burner 60

B-1 High- and Low-Pressure Gas Burners 61

C-1 Combination Burners 62

Unit X - Refrigeration

A-1 Introduction to Refrigeration 63

B-1 Compression System 64
B-2 Compression Cycle 65

C-1 Basic Absorption System 66
C-2 Basic Absorption Refrigeration Cycle 67

D-1 Basic Steam Jet System 68

E-1 Direct and Indirect Refrigeration Systems 69

Unit XI - Refrigeration Equipment

A-1 Compressors 70

B-1 Condensers 71

C-1 Evaporators 72

D-1 Metering Device 73

E-1 Generators 74

F-1 Absorber 75

G-1 Solenoid Valves 76
G-2 Suction-Line Regulators 77

H-1 Dryers 78
H-2 Filters and Strainers 79
H-3 Liquid Flow Indicator 80

Unit XII - Cooling Towers and Ponds

A-1 Spray Ponds 81

B-1 Cooling Towers – Natural and Mechanical 82

C-1 Cooling Water Treatment 83

Unit XIII - Ventilating System and Accessories

Page

A-1 Basic Ventilating System 84

B-1 Ventilating Fans 85

C-1 Duct Work 86

D-1 Air Filters 87

E-1 Washers and Precipitators 88

Unit XIV - Air Conditioning

A-1 Air Conditioning 89

B-1 Air Conditioning Applications 90

C-1 Air Conditioning Cycle 91

Unit XV - Basic Electricity

A-1 Electrical Terminology 92
A-2 Ohm's Law 93
A-3 Solving Electrical Power Problems 94

B-1 Electric Circuits 95
B-2 Series Circuit 96
B-3 Parallel Circuits 97
B-4 Series – Parallel Circuits 99

C-1 Magnetism 100

D-1 Motors (Functions and Types) 101
D-2 Motors (Single, Polyphase and Overload Protection). . 102

Unit XVI - Instruments

A-1 Pressure Gages 103

B-1 Manometers 105

C-1 Thermometers 106

D-1 Thermocouple 107

E-1 Flow Meters 108

F-1 Recorders 109

Unit XVII - Operation

A-1 Boiler Plant Routines 110
A-2 Boiler Plant Startup and Shutdown 111
A-3 Safe Operation of a Boiler Plant 112

Unit XVII - Operation (continued)

	Page
B-1 Routine Startup of a Heating Plant	113
C-1 Ventilating System	114
D-1 Air Conditioning System	115
E-1 Refrigeration Plant Operation	116

Unit XVIII - Service and Maintenance

A-1 Boiler Plant Service and Maintenance (Routine)	117
A-2 Inspection and Cleaning of Boilers	118
B-1 Heating Plant Service and Maintenance	119
C-1 Ventilating System Service and Maintenance	120
D-1 Condenser Maintenance and Service	121
D-2 Evaporator Service and Maintenance	122
D-3 Compressor Maintenance and Service	123

INTRODUCTION

These lessons relate science instruction to the fields of Stationary Engineering, Environmental Control, and Refrigeration. The lessons are brief, but they include a wide range of activities in which science is applied to trade activities. A specific class or student may not be able to study all of the lessons; the instructor may wish to select only certain lessons from the wide range of lessons presented. Each lesson involves concrete trade experiences where science is applied.

Mathematics is also needed as science is applied to these trade areas. The following lessons also involve mathematical problems used in these trade areas:

III-A-2 Pressure-Force Relationship
III-A-4 Pressure Conversion Factors
III-B-2 Force and Distance Applied to Work
III-C-2 Horsepower
III-E-3 Temperature Conversion
III-E-6 Mechanical Equivalent Conversions
III-F-2 Solving Pressure Problems
III-G-2 Solving Pressure-Volume Problems
III-H-2 Solving Pressure-Temperature-Volume Problems
VI-D-2. Use of Force in Reciprocating Pumps
VII-B-2 Fuel Oil Measurement
VIII-C-2 Theoretical Combustion Air Requirements
XV-A-3 Solving Electrical Power Problems
XV-B-2 Series Circuits
XV-B-3 Parallel Circuits
XV-B-4 Series – Parallel Circuits

Objective: Upon completion of this lesson, the student will be familiar with duties, opportunities, and obligations of stationary firemen and stationary engineers.

Aids: Copy of following New Jersey State Department of Labor and Industry, Mechanical Inspection Bureau publications:

a. Licensed Personnel Required for Operation of Boilers and for Operation of Power Generating Plants

b. Licensed Personnel Required for Operation of Steam Boilers, Steam Generators, Hot Water Heating or Similar Equipment Potentially Capable of Generating Steam

c. Guide Rules

d. Application for original license

e. Application for raise of grade

Procedure:

1. Explain in detail all of the opportunities open in the field of stationary engineering.
2. Explain jobs being held by former students.
3. Explain New Jersey Department of Labor and Industry requirements for a license.
4. Explain the difference of the following licenses:
   a. Black seal low pressure
   b. Black seal high pressure
   c. Blue seal engineer
   d. Red seal engineer
   e. Gold seal engineer

   Note: Include duties they are allowed to perform

Summarize:

1. Stress responsibilities that may be assumed by holders of various grades of license.
2. Stress importance of strict adherence to rules and regulations of the New Jersey Department of Labor and Industry.

Testing:

1. Question students on the qualifications necessary to sit for their original license.
2. What are the penalties of operating a plant without the proper license?

Assignment: Complete Assignment 1-A-1 Related Science Manual.

Objective: Upon completion of this lesson, the student will be familiar with the job opportunities in the field of environmental control.

Aids:
1. Newspaper advertisement, i.e. job opportunities in field of environmental control.
2. Trade journals

Procedure:
1. Discuss scope of environmental control.
2. Point out all the related trades and job opportunities.
3. Explain the need for trained mechanics in this field.

Summarize:
1. Why are you interested in this field?
2. What is meant by environmental control?

Assignment: Have student do Assignment 1-B-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be familiar with the job opportunities in the field of refrigeration.

Aids:

1. Newspaper advertisements, i.e. job opportunities in field of refrigeration.
2. Trade journals
3. New Jersey State Department of Labor and Industry, Mechanical Inspection Bureau publication, Licensed Personnel for Operation of Refrigerating Plants Using Flammable or Toxic Refrigerants.

Procedure:

1. Discuss various aspects of the refrigeration field.
2. Point out all job opportunities available to students.
3. Explain the need for trained mechanics in this field.

Summarize: Stress the manpower needs and the full-time aspects of the jobs. The work is not seasonal.

Testing:

1. Why are you interested in refrigeration?
2. How many companies do you know that hire men with refrigeration backgrounds.

Assignment: Complete Assignment I-C-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know how to handle combustible material.
2. Be able to identy the three classes of fires.
3. Be able to identify the types of first aid fire extinguishers and what types of fires they are used on.

Aids: One each of the following extinguishers:

a. Soda - acid
b. Foam
c. CO_2
d. Dry chemical

Procedure:

1. Discuss three things needed to start a fire.
2. Explain three classes of fires.
3. Explain how fires can be put out.
4. Show a sample extinguisher and explain how they work, what class of fire they are best suited for, and why.
5. Discuss the danger of using the wrong type of extinguisher on a fire.
6. Discuss the storage of combustibles.

Summarize:

1. Three things needed for fire
2. Eliminate any one of the above to put out fire
3. Three classes of fires

Testing: Why are water or foam extinguishers dangerous on electric fires?

Assignment: Complete Assignment II-A-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be familiar with the units of force and area.
2. Will be able to define and understand the term pressure.
3. Will be able to be familiar with a barometer and how it measures atmospheric pressure.
4. Will be able to be familiar with the units of pressure.

Aids: Blackboard

Reference: *Principles of Refrigeration*, Roy Dossat

Procedure:

1. Define force. Show how forces can act in any given direction.
2. Define area. Show and explain how to find the area of a circle and a rectangle.
3. Combine force with area to give force per unit of area. Show how the units of force (pounds) and the units of area when combined to give pressure are pounds per square inch, or p.s.i.
4. Sketch a simple barometer on the blackboard and explain how it measures atmospheric pressure.

Summarize:

1. Force-area to pressure.
2. Description and purpose of a simple barometer.
3. Explain units of pressure.

Testing:

1. What is force?
2. What is area?
3. How can you get pressure from force and area?
4. Why do we use a barometer?
5. How could you construct a simple barometer?

Assignment: Complete Assignment III-A-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know how to use the pressure-force-area relationship in problem solving.

Aids: Blackboard

Procedure: Explain the relationship of pressure, force, and area. Show the basic formula:

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Explain how to transpose to solve for force and area. Using the examples from students' Related Science Manual, solve each example as indicated.

Summarize:

1. How to transpose for force and area
2. How to solve the example problems

Testing:

1. What is the formula for pressure?
2. What is the formula for force?
3. What is the formula for area?

Assignment: Complete Assignment III-A-2 in Related Science Manual

Objectives: Upon completion of this lesson, the student will know:

1. How pressure gages function.
2. How manometers function.
3. How bourdon tube gages function.
4. What absolute and gage pressure readings mean.

Aids: Blackboard, U-tubes, cut aways of bourdon tube gages, draft gages.

Reference: *Principles of Refrigeration*, Dossat

Precedure:

1. Show and explain with the use of a sketch how a manometer and a bourdon tube measure pressure.
2. Set up a U-tube and draft gage; demonstrate how they work by changing pressures.
3. Use a cut-away bourdon tube gage and show how the tube moves with changes in pressure. Explain what actually happens inside tube.
4. Show a graph on blackboard of a comparison between gage pressure and absolute pressure. Explain the basic difference and how it is designated – (p.s.i.g.) and (p.s.i.a.).
5. Show a vacuum gage and bourdon pressure gage and explain the difference.

Summarize:

1. Explain how bourdon tube and manometer gages function.
2. Show types of gages (pressure, vacuum, U-tube).
3. Explain absolute and gage pressure.

Testing:

1. What is a pressure gage?
2. How do pressure gages function?
3. What is gage pressure?
4. What is absolute pressure?
5. How do absolute and gage pressure compare?

Assignment: Complete Assignment III-A-3 in Related Science Manual

Objectives: Upon completion of this lesson, the student will know:

1. The pressure conversion factors.
2. How to convert from foot head to pounds per square inch.
3. How to convert from inches of mercury column to pounds per square inch.
4. How to convert from absolute pressure to gage pressure.

Aids: Blackboard

Procedure:

1. Use Sketch III-A-4-1. Explain that 1" of water = .0361 p.s.i. 12" = .433 p.s.i.
2. Explain that pressure equals .433 p.s.i. times VF at the base of a column.
3. Show how knowing pressure you can find vertical feet
4. Use Sketch 3-A-4-1. Explain that 1" of mercury equals .491 p.s.i. 30" = 14.7 p.s.i.
5. Use Sketch 3-A-4-2. Explain gage pressure, absolute pressure, and vacuum.
6. Define vacuum.
7. Explain vacuum reading in inches of mercury (HG).
8. Show how to convert inches of mercury to absolute pressure.

Summarize:

1. 1 vertical foot of water = .433 p.s.i.
2. 1 vertical inch of mercury = .491 p.s.i.
3. Absolute pressure = gage pressure + atmospheric pressure
4. Vacuum to absolute pressure 14.7 (vacuum X .491)

Testing: When there is a falling barometer, does this affect the atmospheric pressure? Does it increase or decrease?

Assignment: Complete Assignment III-A-4 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be familiar with the terms force and distance as applied to work.
2. Know how to measure the amount of work done.
3. Know which units to use to measure work.

Aids: Blackboard

Procedure:

1. With the use of a blackboard show a force pulling an object.
2. Define force and explain that work will be done if the object is moved by the applied force.
3. Show how to calculate the amount of work done by finding the product of the force and the distance the object was moved. (Assume values) $W = f \times d$.
4. Explain how the product of units of force (pounds) and units of distance (feet) equals foot-pounds.

Summarize: Explain relationship of force, distance and work. Explain how to measure work and the units used.

Testing:

1. How is force and distance measured in relation to work?
2. How is the amount of work that is done measured?
3. Would any work be performed if two equal forces opposed each other to move a weight?

Assignment: Complete Assignment III-B-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be able to figure foot-pounds of work done.

Aids: Blackboard

Procedure:

1. Define force.
2. Explain how work involves force and distance.
3. Explain units of measuring force and distance to get foot pounds.
4. Do sample problems.

Summarize:

1. Force
2. Work
3. Foot-pounds

Testing: Why is it necessary to move a weight a distance to do work?

Assignment: Complete Assignment III-B-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will know the meaning of:

1. The terms, power and horsepower.
2. Be able to relate power to work and time.
3. Understand the relationship between power and horsepower.

Procedure:

1. Define work and introduce a time factor. Build this into a rate of doing work or power.
2. Explain the units that are used in work, (ft.lbs.) time,(sec. or min.).
3. Explain that power is a rate of doing work.
4. Define a horsepower and show that it is a definite amount of work per unit of time.

Summarize:

1. Relate work, time, power, and horsepower.
2. Show units of each in detail.

Testing:

1. Define work, time, power, and horsepower.
2. What does work per unit of time refer to?
3. How many foot-pounds per minute are put out to equal two horsepower?

Assignment: Complete Assignment III-C-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be able to figure horsepower problems.

Aids: Blackboard

Procedure:

1. Explain that power is the rate of doing work.
2. Power = $\frac{\text{work}}{\text{time}}$
3. Work = pounds X feet
4. Power = $\frac{\text{foot-pounds}}{\text{time}}$
5. Discuss experiment, i.e., horse lifting 550#'s 1 ft. in 1 sec. or 33,000#'s 1 foot in 1 min.
6. 1 mechanical horsepower = 33,000#'s/min.
7. Do sample problem

Summarize:

1. Power = rate of doing work
2. Power = $\frac{\text{work}}{\text{time}}$
3. Power = $\frac{\text{ft. lbs.}}{\text{time}}$
4. 1 m.h.p = 33,000 ft. lbs./min.

Testing: How does power differ from work?

Assignment: Complete Assignment III-C-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know what energy is.
2. Know the difference between potential and kinetic energy.

Procedure:

1. Explain that work can be stored and that when it is stored it is known as energy.
2. Show that energy is measured in foot-pounds the same as work.
3. Explain what potential and kinetic energy is and give examples of each.
4. Explain that energy is required to do work and that energy cannot be created or destroyed.

Summarize:

1. Energy is stored work and is measured in foot-pounds.
2. Explain potential and kinetic energy in its various forms.

Testing:

1. Name some forms of potential energy.
2. Name some forms of kinetic energy.
3. How can we define energy?

Assignment: Complete Assignment III-D-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Recognize heat as a form of energy.
2. Recognize that heat or removal of heat can affect the state of a substance.

Procedure:

1. Explain that heat is a form of energy and that basically it is in the form of kinetic energy due to the molecular motion within a substance.
2. Explain solid, liquid, and gaseous states. Emphasize the addition or removal of heat to affect the change.

Summarize:

1. Heat is energy in a kinetic form.
2. Molecular motion.
3. Three states of matter.

Testing:

1. What form of energy is heat?
2. What is molecular motion?
3. What causes molecular motion?
4. What three states can a substance be in?

Assignment: Complete Assignment III-E-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be able to read the scales used on thermometers.
2. Know what temperature is.
3. Know what the term British thermal unit is.
4. Know the difference between latent and sensible heat.

Aids: Thermometers, pyrometer, blackboard

Procedure:

1. Show and explain the scales on the thermometers.
2. Draw a graph comparing Fahrenheit and Centigrade scales down to Absolute Zero.
3. Explain that temperature is the intensity of heat. This can be explained by the comparison of the total heat in a lake at 60°F. temperature and the heat in a pot of water at 200°F. (Use term quantity of heat.)
4. Explain that heat is measured in terms of British thermal units and define a B.t.u.
5. Show and explain with the use of a sketch (on blackboard) the meaning of sensible and latent heat. Start with ice at 0°F. and go through to steam at 212°F.
6. Explain latent heat of fusion and evaporation. Sketch on the board can be used.

Summarize:

1. Thermometer used had Fahrenheit and Centigrade scales.
2. Absolute Zero molecular motion stops.
3. Temperature is intensity of heat.
4. B.t.u.'s is the quantity of heat.
5. Define B.t.u. latent, and sensible heat.
6. Define latent heat of fusion and evaporation.

Testing:

1. What does a thermometer measure?
2. What does temperature indicate?
3. What is a B.t.u.?
4. What is latent heat?
5. What is sensible heat?
6. What is latent heat of fusion and evaporation?

Assignment: Complete Assignment III-E-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will be able to:

1. Convert °F. to °C.
2. Convert °F. to Absolute Scale.
3. Convert °C to °F.
4. Convert °C to Absolute Scale.

Aid: Blackboard

Procedure:

1. Put Chart III-E-3-1 from Related Science Manual on the board.
2. Explain the fixed points on both scales.
3. Explain why 180°F. is equal to 100°C.
4. Develop the formula for °F.
5. Develop the formula for °C.
6. Work out sample problems in each scale.

Summarize:

1. Fixed point on both scales
2. Relationshop between °C and °F.

Testing: Sample problem

Assignment: Complete Assignment III-E-3 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be able to describe the three methods of heat transmission and give examples of each.

Aids: Blackboard

Procedure:

1. Explain that heat flows from the high temperature to the low temperature area.
2. Explain that the heat transfer rate is directly proportional to the temperature difference between the two substances.
3. Show by the use of sketch and explain the three methods of heat transmission (radiation-conduction-convection). Give examples of each method.

Summarize:

1. Heat flow from high to low temperature.
2. Heat transfer rate is proportional to temperature difference.
3. The three methods of heat transmission.

Testing:

1. Explain how heat flows in a substance.
2. What do we mean by heat transfer rate?
3. What are the methods of heat transmission?
4. Describe each method of heat transmission.

Assignment: Complete Assignment III-E-4 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will be able to:

1. Define mechanical equivalent of heat.
2. Convert heat units (B.t.u.'s) into mechanical units (ft.lbs.)

Procedure:

1. Explain that heat is a form of energy and can be converted into other forms.
2. Explain the ft.lb. and B.t.u. as energy units.
3. Explain what the mechanical equivalent of heat is and how it was arrived at.
4. Show how to convert from B.t.u. to ft.lbs. and how to go from ft.lbs. to B.t.u.'s.

Summarize:

1. Heat energy can be converted into other forms.
2. Mechanical equivalent of heat.
3. How to convert units.

Testing:

1. What is the mechanical equivalent of heat?
2. How was it derived?
3. How can we convert energy units?

Assignment: Complete Assignment III-E-5 in Related Science Manual.

Objectives Upon completion of this lesson, the student will be able to:

1. Convert B.t.u.'s to foot-pounds.
2. Convert foot-pounds to B.t.u.'s.

Aids: Blackboard

Procedure:

1. Define:
   a. Heat
   b. Energy
   c. Intensity of heat (°F – °C)
   d. B.t.u.
   e. Force
   f. Work
   g. Mechanical equivalent of heat (778 ft-lb)
2. Show how they relate to one another.
3. Explain: ft-lb's = B.t.u. X 778 B.t.u. = $\frac{\text{ft-lb's}}{778}$
4. Solve sample problem.

Summarize:

1. Mechanical equivalent of heat (778 ft-lb's)
2. Formula

Testing:

1. What is heat?
2. What is energy?
3. What is force?
4. What is a B.t.u.?
5. What is work?

Assignment: Complete Assignment III-E-6 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the volume-temperature relationship of gases when the pressure remains constant.
2. Know the temperature-pressure relationship of gases when the volume remains constant.
3. Know how to apply Charles' Laws.

Aids: Blackboard

Procedure:

1. Show and explain with a sketch how the volume of a gas changes with temperature changes.
2. Pressure must remain constant. Show and explain with a sketch how the pressure of a gas changes with temperature changes.
3. Volume must remain constant. Explain the units of pressure, temperature, and volume used. P = p.s.i.a., V = cu. ft., T = °Ranking = °F + 460°. Show and explain how to use formulas.

$$\frac{V1}{T1} = \frac{V2}{T2} \quad \text{constant pressure}$$

$$\frac{P1}{T1} = \frac{P2}{T2} \quad \text{constant volume}$$

Summarize:

1. How pressure, temperature, and volume of gases have a definite relationship.
2. How to use the gas equations.

Testing:

1. How is the pressure, temperature, and volume of gases related?
2. What units do you use for pressure, temperature, and volume?
3. What are the formulas that are based on Charles' Laws?

Assignment: Complete Assignment III-F-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be able to use Charles' Gas Laws to solve volume and pressure problems.

Aids: Blackboard

Procedure:

1. Explain that if the pressure on a gas is kept constant, its volume will change proportionally with its temperature.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

2. Show and explain how to use the above formula. Use the following values:

$V_1 = 10$ cu.ft. $V_2 = 12$ cu.ft.

$T_1 = 90°F$ $T_2 = 200°F$

3. Explain that if the volume of a gas is kept constant, its pressure would change proportionally with its temperature.

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

4. Show and explain how to use the above formula. Use the following values:

$P_1 = 100$ p.s.i.a $T_1 = 90°F$

$P_2 = 120$ p.s.i.a. $T_2 = 200°F$

Summarize:

1. Stress that units are: pressure = p.s.i.a.; temperature = °Rankine; volume = cubic feet.
2. Substitute and solve for each formula.

Testing:

1. Transpose each formula to solve for each unknown value:

$$V_1 = \frac{V_2 \times T_1}{T_2} \quad V_2 = \frac{V_1 \times T_2}{T_1} \quad T_1 = \frac{V_1 \times T_2}{V_2} \quad T_2 = \frac{V_2 \times T_1}{V_1}$$

2. Do the same for constant volume.
3. Using the values from 2 & 4 of the procedure, solve for each unknown.

Assignment: Complete Assignment III-F-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the pressure-volume relationship of gases when the temperature remains constant.
2. Know the formula derived from Boyle's Law.

Aids: Blackboard

Procedure:

1. Show and explain with a sketch how the volume changes when the pressure is changed providing there is no change in temperature.
2. Explain the units of pressure and volume that are used.
3. Show and explain how to use Boyle's gas formula.

$$P_1 = \frac{1}{V_1} \qquad P_2 = \frac{1}{V_2}$$

$$P_1 V_1 = P_2 V_2 \text{ at a constant temperature.}$$

Summarize:

1. Boyle's Law: volume-pressure change at a constant temperature.
2. Units of pressure and volume.
3. $P_1 V_1 = P_2 V_2$

Testing:

1. What does Boyle's Law tell us?
2. State Boyle's Law in a formula.
3. What units are used?

Assignment: Complete Assignment III-G-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be able to solve pressure-volume problems by using Boyle's Law.

Aids: Blackboard

Procedure:

1. Explain Boyle's Law: the volume of a gas will vary inversely with its pressure if the temperature remains constant.
2. Show and explain the formulas: $P_1 = \frac{1}{V_1}$ $P_2 = \frac{1}{V_2}$ and $P_1 V_1 = P_2 V_2$

   Show how to transpose to solve for any unknown.

   $P_1 = \frac{P_2 V_2}{V_1}$ $V_1 = \frac{P_2 V_2}{P_1}$ $P_2 = \frac{P_1 V_1}{V_2}$ $V_2 = \frac{P_1 V_1}{P_2}$

3. Using the following values set up problems and solve:
   $P_1 = 50$ $V_1 = 210$ $P_2 = 150$ $V_2 = 70$

Summarize: Transposing and solving problems in number 3 in the procedure.

Testing: Transpose to solve for each unknown in the formula $P_1 V_1 = P_2 V_2$ using the values of number 3 in the procedure above for each unknown.

Assignment: Complete Assignment III-G-2 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know what the General Gas Law is.

Aids: Blackboard

Procedure:

1. Review Charles' Laws: $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\frac{P_1}{T_1} = \frac{P_2}{T_2}$
2. Review Boyle's Law: $V_1 P_1 = V_2 P_2$. Show that by combining the above two laws, you finish with $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$
3. The pressure is in p.s.i.; the volume is in cu.ft.; and the temperature is in °Rankine.

Summarize: The General Gas Law is derived from the combining of Charles' Laws and Boyle's Law.

Testing:

1. What are Charles' Laws?
2. What is Boyle's Law?
3. What is the General Gas Law?

Assignment: Complete Assignment III-H-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be able to solve pressure-temperature-volume problems using the General Gas Law.

Aids: Blackboard

Procedure: Show that by combining Charles' and Boyle's Laws:

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ and $P_1 V_1 = P_2 V_2$ that you find: $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

Show how to transpose for each unknown value:

$P_1 = \frac{P_2 V_2 T_1}{V_1 T_2}$ $V_1 = \frac{P_2 V_2 T_1}{P_1 T_2}$ $T_1 = \frac{P_1 V_1 T_2}{P_2 V_2}$ $P_2 = \frac{P_1 V_1 T_2}{T_1 V_2}$

$V_2 = \frac{P_1 V_1 T_2}{T_1 P_2}$ $T_2 = \frac{P_2 V_2 T_1}{P_1 V_1}$

Using the following values, set up problems and solve:

$P_1 = 50$; $V_1 = 10$; $T_1 = 1000$; $P_2 = 100$; $V_2 = 2.5$; $T_2 = 500$.

Summarize:

1. How to transpose
2. Substituting values in formula

Testing: Transpose to solve for each unknown in the formula $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

Using the values from above, substitute the values and solve.

Assignment: Complete Assignment III-H-2 in the Related Science Manual.

Objectives: Upon completion of this lesson the student will know:

1. The meaning of the term, saturated vapor.
2. The meaning of the term, superheated vapor.

Aids: Blackboard

Procedure:

1. Show a diagram of a container of water with heat being applied and with vapor above it.
2. Explain what the pressures and temperatures are in the liquid and in the vapor.
3. Explain that the boiling point of various liquids are not the same.
4. Using the same basic diagram, add a heater to the vapor side.
5. Explain how the temperature of the vapor increases without an increase in pressure.

Summarize: Explain and define the terms: saturated vapor and superheated vapor.

Testing:

1. What is meant by the term saturated vapor?
2. What is meant by the term superheated vapor?

Assignment: Complete Assignment III-I-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know a basic steam heating system.

Aids:

1. Sketch of basic steam heating system
2. Manufacturers data sheets

Procedure:

1. Sketch on board showing simple basic steam heating system (or use overhead).
2. Sketch on board and explain system having more than one heater. Bring in main steam line main branches, risers, heater traps, and return line to boiler. Show how air is removed from system.
3. At this time tie in various parts of the system and the purpose they play.
4. Define condensate.
5. Explain the function of any steam heating system and how it accomplishes its function.

Summarize:

1. Main function of heating system.
2. How it goes about achieving its function.

Testing:

1. Question students about following:
   a. Function of heating system.
   b. What will happen to steam when it gives up its heat?
   c. Why are valves placed in the system?

Assignment: Complete Assignment V-A-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know the difference between pressure and vacuum heating systems.

Aids:

1. Sketch of following:
   a. Basic pressure heating system
   b. Basic vacuum heating system
2. Vent valves
   a. Radiator
   b. Quick vent

Procedure:

1. Sketch for class showing basic pressure heating system including vents on mains and heater.
2. Sketch for class showing basic vacuum system
3. Explain to students where vents are found and how they work.
4. Explain air bound heater.
5. Explain vacuum system.

Summarize:

1. Explain basic difference, i.e., pressure-vacuum system.
2. Importance of adjustable vent and quick vent valves.
3. Stress where and why quick vent valves are used.
4. Stress what happens in air bound heaters.

Testing:

1. Ask students to explain basic difference i.e., pressure-vacuum system.
2. Ask students if they have ever had a cold heater in their home or a room that was hard to heat? Can they correct the problem now from what they have learned?

Assignment: Complete Assignment V-A-2 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know how a basic hot water heating system works.

Aids:
1. Sketch of basic hot water heating system.
2. Manufacturers' data sheets and catalogs

Procedure:
1. Sketch a basic hot water heating system.
2. Explain the difference between steam and hot water systems.
3. Tie in the basic parts of the system and the function they serve.
4. Explain why steam heaters can be smaller than hot water heaters.

Summarize:
1. Basic difference between steam and hot water systems.
2. Stress difference in heater sizing.

Testing:
1. What is heating medium used in steam and in hot water heating system?
2. Why do hot water systems require larger heaters?

Assignment: Complete Assignment V-B-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know how a natural (or gravity) hot water circulation heating system works.

Aids:

1. Sketch of basic natural hot water heating system
2. Manufacturers' data sheets and catalogs

Procedure:

1. Sketch a basic natural circulation system.
2. Explain what happens to water when heated:
   a. Expands
   b. Increase in volume
   c. Decrease in density
3. Explain how this causes natural circulation.
4. Explain location, purpose, and need for the expansion tank.
5. Explain reason for large heaters and pipes in a natural circulation system.

Summarize:

1. Stress what happens to heated water.
2. Stress how this is cause of natural circulation.
3. Stress importance of expansion tank.

Testing:

1. Ask students to give an example of natural circulation other than in a hot water system.
2. Ask them to explain how and why this circulation is possible.

Assignment: Complete Assignment V-B-2 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know how a forced circulation hot water heating system works.

Aids:

1. Sketch of simple forced circulation hot water heating system (board, overheat, etc.)
2. Manufacturers' data sheets and catalogs

Procedure:

1. Sketch a simple forced circulation system.
2. Explain why a circulating pump was introduced to the system.
3. Explain why this enabled the use of smaller pipes and heaters.
4. Explain the purpose of the following:
   a. Flow control valve
   b. Diverter fitting
   c. Compression tank
   d. Relief valve
   e. Pressure reducing valve
5. Explain why they are not found in the natural circulation system.

Summarize:

1. Use of pump to increase velocity of water flow
2. Why smaller heaters and lines can be used
3. What protects system from over pressure?
4. Why must additional fittings be used in forced circulation system?

Testing:

1. Have students explain difference between expansion and compression tank.
2. What protects each of the two hot water systems studied from over pressure?
3. Explain some of the advantages of forced circulation system over the natural circulation.

Assignment: Complete Assignment V-B-3 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know how a basic warm air heating system works.

Aids:

1. Sketch of basic warm air heating system (board, overhead, etc.)
2. Manufacturers' data sheets and catalogs

Procedure:

1. Sketch a basic warm air heating system.
2. Explain the medium used to deliver the heat to the room.
3. Explain what happens to air when heated. Air is fluid; that is why it reacts the same as water when heated.
4. Explain that cast iron furnace joints are made tongue and groove and then sealed with furnace cement to prevent gases of combustion entering room being heated.

Testing:

1. Is this system very effective? What are some of the advantages and disadvantages.
2. What are the dangers of gases of combustion in living areas?

Assignment: Complete Assignment V-C-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know how a natural circulation warm air heating system works.

Aids:

1. Sketch of natural circulation warm air heating system.
2. Manufacturers' data sheets and catalogs

Procedure:

1. Sketch a natural circulation warm air system.
2. Explain what causes air to circulate in a warm air system of this type.
3. Explain why design plays such an important part in proper operation.
4. Briefly mention why duct work going to a third floor will be smaller in area than those heating a second floor, and explain why the second floor ducts are smaller in area than those heating a first floor.
5. Calculate warm air pipe sizes by:
   a. Calculate heat loss for each room. (Refer to Chapter 21, Domestic Oil Burners and Oil heat.)
   b. Divide the room B.t.u. loss by 1000.
   c. For 1st floor rooms, multiply by 9.
   d. For 2nd floor rooms, multiply by 6.
   e. For 3rd floor rooms, multiply by 5.

   Example:
   1. 8241 B.t.u. loss
   2 8241 ÷ 1000 = 8.2
   3. 8.2 X 9 = 73.8 or 74

   Leader to 1st floor must have cross sectional area of 74 sq. inches to heat properly.
6. Explain that the higher the riser the greater the force of air movement. This will cause more B.t.u.'s to be delivered through a square inch of duct. The draft is stronger when the stack is higher.

Testing:

1. If, when air is heated it loses density, what makes it rise?
2. Why is it possible to use smaller ducts when warm air is brought to a higher elevation than a lower elevation?

Assignment: Complete Assignment V-C-2 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know how a forced circulation warm air heating system works.

Aids:

1. Sketch of a forced circulation warm air heating system.
2. Manufacturers' data sheets and catalogs

Procedure:

1. Sketch a forced circulation system.
2. Explain purpose and location of blower in system.
3. Explain why the use of a blower makes possible the use of smaller heating ducts.
4. Explain purpose and location of filters.
5. Explain why filters cannot be used in natural circulation systems.
6. Explain the advantage of continuous furnace operation.

Testing: Do you have any idea of why a blower is belt driven rather than a direct drive from a motor?

Assignment: Complete Assignment V-C-3 in Related Science Manual.

Objective: Upon completion of this lesson, the student will:

1. Know what firetube boilers are.
2. Be able to identify the various types of firetube boilers.

Aids:

1. Overhead projector
2. Transparencies of various types of firetube boilers.

Procedure:

1. Describe a firetube boiler.
2. Show different types of firetube boilers.
3. Explain what is meant by internally and externally fired boilers.
4. Explain why plant steam demands rule out use of firetube boilers.
5. Explain what the A.S.M.E. code is.

Summarize:

1. Firetube boiler definition
2. Classification
3. General use
4. Limitations

Testing: Why do you think it important that boiler manufacturers should adhere to the A.S.M.E. construction code?

Assignment: Complete Assignment VI-A-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will:

1. Know what a watertube boiler is.
2. Be able to identify the various types of watertube boilers.

Aids:

1. Overhead projector
2. Transparencies of various types of watertube boilers

Procedure:

1. Define a watertube boiler.
2. Show the different types of watertube boilers.
3. Explain the difference between internally and externally fired boilers.
4. Explain why an increase in steam pressure and capacity made the development of watertube boilers a necessity.

Summarize:

1. Watertube boiler definition
2. Classification
3. General use

Testing: If you were in charge of a plant that generated power and had to pick out a boiler, what type would you select and why?

Assignment: Complete Assignment VI-A-2 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be familiar with a cast-iron sectional boiler.

Aids:

1. Overhead projector
2. Transparencies of cast-iron sectional boilers

Procedure:

1. Define a cast-iron sectional boiler.
2. Show the different types of cast-iron boilers.
3. Explain why they are not a watertube boiler.
4. Explain why they are only used for low pressure.
5. Explain how sections can be added for larger buildings.

Summarize:

1. Cast-iron definition
2. General use and limitations
3. Can be steam or hot water

Testing: Why do you feel cast-iron boilers are not suitable for high pressure work?

Assignment: Complete Assignment VI-A-3 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be familiar with the necessary trim needed to operate a steam boiler.

Aids:

1. Overhead projector
2. Transparency of steam boiler schematic showing trim

Procedure:

1. Explain what is meant by boiler trim.
2. Explain that steam trim is different from water trim. Explain location of steam trim.
3. Explain that steam trim can be the same on low-pressure as well as high-pressure boilers. Only the material that it is made of will vary.
4. Explain reason for trim, i.e., efficiency and safety.
5. Explain how the name almost always denotes the use of the trim.

Summarize:

1. Why is trim the same on high and low pressure?
2. Why is high-pressure steam trim made of different material?

Testing:

1. Why do you think it is necessary to use different material in high-pressure boilers?
2. Why is location of trim so important?

Assignment: Complete Assignment VI-B-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be familiar with the necessary trim needed to operate a hot water boiler.

Aids:
1. Overhead projector
2. Transparency of hot water boiler schematic showing trim

Procedure:
1. Explain that trim on a hot water boiler serves the same purpose as trim on a steam boiler.
2. Show and explain location of hot water trim.
3. Explain how boilers are built the same and that they only differ when steam or water trim is added.

Summarize:
1. Hot water trim and steam trim serve same purpose.
2. Difference is in median that they must control.
3. Stress importance of knowing location and purpose.

Testing:
1. Why aren't hot water boilers equipped with a water column, gage glass, and tri-cocks?
2. What is the main difference between a steam and a hot water boiler?

Assignment: Complete Assignment VI-B-2 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be familiar with the steam accessories and know what they are used for.

Aids:

1. Overhead projector
2. Transparency of steam system showing location of steam accessories

Procedure:

1. Define steam accessories.
2. Trace flow of steam from boiler to heater.
3. Explain purpose of each piece of equipment.
4. Explain why condensation takes place in steam line.
5. Explain why gate valve offers no restriction to flow of steam and why this is important.

Summarize: Stress importance of knowing location and purpose of each piece of equipment in system.

Testing:

1. Do you feel it is necessary to know where and why steam accessories are used?
2. Is there any way to cut down on condensation losses in steam lines.

Assignment: Complete Assignment VI-C-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know where hot water accessories are located and what function they perform in a system.

Aids:

1. Overhead projector
2. Schematic of hot water system showing all accessories as well as hot water trim (transparency)

Procedure:

1. Define hot water accessories.
2. Trace flow of water from boiler back to boiler.
3. Explain why accessories are needed and how they work.
4. Explain reason for elimination of air from system.
5. Explain how and why the relief valve should be tested.
6. Explain what happens when the compression tank becomes water-logged and how to drain it.
7. Explain why reducing valve strainers must be kept clean.
8. Explain danger of tampering with the adjustment of the reducing valve.
9. Show on board how head of water can be converted to pressure.

Summarize: Quick review of system and parts

Testing:

1. What do you think would cause a compression tank to become waterlogged? How could you check this out?
2. Since there is no gage glass on a hot water boiler how can you determine if the boiler is full of water?

Assignment: Complete Assignment VI-C-2 in Related Science Manual.

Objective: Upon completion of this lesson, the student will identify the location and know the purpose of the following in a warm air system:

1. Ducts
2. Filters
3. Blowers
4. Humidifiers

Aids:

1. Basic Warm Air System transparency
2. Natural Circulation System transparency
3. Forced Circulation System transparency
4. Overhead projector

Procedure:

1. Explain the basic warm air heating system – its operation and limitations. (Use overhead.)
2. Explain the natural circulation heating system – its operation and limitations. (Use overhead.)
3. Explain the forced circulation heating system – its operation and advantages over the other two systems.
4. Explain the reasons for return air ducts.
5. Explain the purpose of dampers located on supply ducts.
6. Explain how to balance the heating load.
7. Explain the location and purpose of filters.
8. Explain what happens when filters are dirty or clogged.
9. Explain purpose and location of blower.
10. Explain why blowers are belt-driven and are run at slow speeds.
11. Explain location and reasons for using a humidifier.
12. Discuss maintenance requirement of:
    a. filters
    b. blowers
    c. humidifiers

Summarize: Brief discussion of the three systems including their limitations and advantages.

Testing: What would happen if you ran the blower with a direct drive and at high speed.

Assignment: Complete Assignment VI-C-3 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the theory of operation.
2. Know the purpose and location of reciprocating pumps.
3. Know the meaning of the data found on the name plate.

Aids:

1. Blackboard
2. Sketch of boiler showing steam line to pump and discharge line to boiler. (Include steam pressure and water pressure.)

Procedure:

1. Put sketch on board and ask if anyone can explain how a pump using 100 p.s.i. of steam can deliver 400 p.s.i. of water pressure.
2. Explain the design of pump steam piston, which is 2– 2½ times larger in area than the water piston.
3. Explain what is meant by total force (area X pressure).
4. Explain what is meant by: total force on steam side of pump = total force on water side of pump.
5. Use pump data: 4 X 2 X 8 steam pressure 100 p.s.i. Show how to find the water pressure developed by the steam pressure.

Total Force Steam Side = Total Force Water Side

Area Steam Side X Steam Pressure = Area Water Side X Water Pressure

$(d_{ss})^2 \times .7854 \times \text{Steam Pressure} = (d_{ws})^2 \times .7854 \times \text{Water Pressure}$

$4 \times 4 \times .7854 \times 100 = 2 \times 2 \times .7854 \times \text{Water Pressure}$

$12.5664 \times 100 = 3.1416 \times \text{Water Pressure}$

$$\frac{12.5664 \times 100}{3.1416} = \text{Water Pressure}$$

$$\frac{1256.64}{3.1416} = \text{Water Pressure}$$

$$400 = \text{Water Pressure}$$

6. Explain again why steam piston of feed pump must be 2– 2½ times larger in area than water piston.
7. Explain the purposes of the reciprocating pump other than as a feed water pump.
8. Explain the reason for various locations.
9. Explain cover name plate data and what it means.

Summarize:

1. Theory of operation
2. Name plate data

Testing:

1. What do figures on name plate data indicate?
2. How do you find the total force developed on the steam side of pump? On water side?
3. Pump = $\frac{4 \times 3 \times 6}{6 \times 8 \times 12}$

   Which would be used as feed water pump?

Assignment: Complete Assignment VI-D-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Understand what is meant by *total force = total force.*
2. Find the steam pressure needed knowing the water pressure developed when using *total force = total force.*
3. Find the water pressure developed knowing the steam pressure on hand when using *total force = total force.*

Procedure:

1. Explain that force is push or pull. Pressure is force acting on a body per unit of area; this can be pounds per square inch or pounds per square foot.
2. Area of circle = $D^2 \times .7854$ or πR^2. Explain why we usually use $D^2 \times .7854$.
3. Explain pounds per square inch. (p.s.i.).
4. Explain what is meant by an equation.
5. Explain what is meant by total force = total force. (Use figures to prove it.)
6. Explain how to solve for steam pressure.
7. Explain how to solve for water pressure.
8. Solve sample problems.

   Pump $4 \times 2 \times 6$ steam pressure 150 p.s.i. Find water pressure.
   Pump $3 \times 1.5 \times 4$ water pressure 150 p.s.i. Find steam pressure.

Summarize:

1. Total force = total force
2. Show how to transpose and solve for unknowns.
3. Show how to prove answer testing.

Testing: Using the formula, *total force = total force,* have students develop formula for finding (a.) steam pressure and (b.) water pressure.

Assignment: Complete Assignment VI-D-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the students will:

1. Be familiar with the theory of operation.
2. Know the purpose and location of centrifugal pumps.
3. Know the parts of a centrifugal pump.

Aids:

1. Transparency of centrifugal pump.
2. Overhead projector.
3. Cut-away model of centrifugal pump.

Procedure:

1. Explain centrifugal force, kinetic energy, and potential energy.
2. Use overhead projector and show transparency of centrifugal pump.
3. Indicate parts of a centrifugal pump and explain their function.
4. Explain operation of a centrifugal pump and tell how it pumps liquid.
5. Explain the different pump applications and how they affect the design of the pump.
6. Describe the method of drive (motor or steam turbine) and how it is connected.

Summarize: Discuss theory of pump operation, application, and function of pump parts.

Testing:

1. How does a centrifugal pump move liquid?
2. Name some of the parts that make up a centrifugal pump. Tell what their function is.
3. What are some of the services that use centrifugal pumps?

Assignment: Complete Assignment VI-D-3 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be familiar with the theory of operation.
2. Know the purpose and location of the rotary and vacuum pump.
3. Know the parts of a rotary pump.

Aids:

1. Rotary pump transparency
2. Vacuum return pump system transparency
3. Overhead projector
4. Cut-away model of rotary pump

Procedure:

1. Explain theory of operation for a rotary pump.
2. Classifications of rotary pumps with brief explanation on how they operate.
3. Discuss the types of liquids that rotary pumps can handle and the services they can be used for.
4. Discuss the parts of a rotary pump.
5. Explain the purpose of a vacuum pump – where it is located.

Summarize:

1. Discuss the theory of operation of a rotary pump.
2. Briefly discuss the different types of rotary pumps.
3. Discuss the location and purpose of rotary and vacuum pumps.
4. Discuss the parts of a rotary pump.

Testing:

1. Describe the operation of a rotary pump.
2. Name the parts of a rotary pump.
3. Name some of the different types of rotary pumps.
4. What is the purpose of a vacuum pump? Where is it located?
5. What type of liquids and services use a rotary pump?

Assignment: Complete Assignment VI-D-4 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose of the feed-water system.
2. Know the purpose and location of all the equipment found in the system.
3. Understand the importance of knowing the system intimately.
4. Understand the danger of low water.

Aids:

1. Transparency sketch 7-A-1-1
2. Overhead projector

Procedure:

1. Explain the 3 basic systems needed to operate a boiler.
2. Explain why the feed-water system is so important.
3. Explain how you need 1 pound of water to make 1 pound of steam.
4. Explain the danger of low water and why a boiler explodes (drop in pressure without drop in temperature).
5. Use transparency 7-A-1-1 and trace water from heater to boiler; explain the function of all equipment.
6. Explain why heater must be vented and the danger in using an open heater.

Summarize:

1. Importance of knowing every possible way of getting water to boiler
2. Danger high and low water
3. Dangers, i.e., open heater

Testing:

1. Why is one steam and one electric pump recommended?
2. How would you get water to the boiler if the regulator failed?

Assignment: Complete Assignment VII-A-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will be able to:

1. Know the purpose of the feed-water system.
2. Identify and describe the purpose of the equipment found in the system.
3. Explain the importance of a complete knowledge of the system.
4. Explain why low water is dangerous.

Aids:

1. Transparency sketch 7-A-2-1
2. Overhead projector

Procedure:

1. Use transparency 7-A-2-1; trace water from vacuum pump to boiler
2. Explain the function of all equipment and fittings in the system.
3. Explain what controls the starting of the vacuum pump.
4. Explain the need for automatic city water make-up.
5. Explain the need for a by-pass around the automatic city water make-up.

Summarize:

1. Basic steam to water cycle
2. Need for proper operating procedure (testing equipment)

Testing:

1. Have student explain what controls the starting of the vacuum pump.
2. Have student explain the purpose of 3-way selector switch.

Assignment: Complete Assignment VII-A-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be familiar with a basic fuel oil system.
2. Be able to identify the parts in a fuel oil system.
3. Know the purpose of the parts in the fuel oil system.

Aids:

1. Transparency of fuel oil system, 7-B-1-1
2. Overhead projector

Procedure:

1. Show the fuel oil system in 7-B-1-1.
2. Identify and explain the purpose of parts in the fuel oil system.
3. Trace the flow of the fuel through the system.

Summarize: Discuss the fuel oil system with students showing flow of oil through system and stressing the function of parts in the system.

Testing:

1. Name some things that are found in a fuel oil system, and explain what they are used for.
2. Why is it important to have pressure and temperature gages in the fuel oil system? Could you operate the system without them? Explain.
3. Why is some oil recirculated back to the fuel oil tank?
4. Why is it important to be able to isolate some equipment in the system?

Assignment: Complete Assignment VII-B-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know how a fuel oil tank is calibrated.
2. Be able to figure fuel oil readings.
3. Be able to figure fuel oil consumption.

Aids:

1. Blackboard
2. Fuel oil chart

Procedure:

1. Explain how tank is calibrated.
2. Show how to change a reading of feet and inches to inches.
3. Explain how to read a chart to get gallons.
4. Explain how to interpolate and find gallons per ½ inch.

Summarize:

1. How to change feet and inches to inches
2. How to read chart
3. How to interpolate

Testing: Have students work out a few problems in interpolation.

Assignment: Complete Assignment VII-B-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know what is meant by draft.
2. Be able to explain why draft is necessary in a boiler.
3. Be able to measure draft.

Aids:

1. Transparencies 7-C-1-1, 7-C-1-2, and 7-C-1-3
2. Overhead projector
3. U-tube manometer

Procedure:

1. Define draft. Explain why it is necessary.
2. Explain where draft measurements are taken.
3. Explain a U-tube manometer and how it works.
4. Explain how to change inches of water to pounds pressure, i.e.,

   1 cu.ft. water weights 62.4 pounds
   1 cu.ft. = 1 728 cu.inches

   $$\frac{62.4}{1728} = .0361 \text{ p.s.i.}$$

5. Use transparency sketch 7-C-1-3. Show how height is related to pressure.

Summarize:

1. How draft is measured
2. How to change inches of water to pressure

Testing: Why is draft needed and what function does it serve?

Assignment: Complete Assignment VII-C-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know what natural draft is.
2. Know what mechanical draft is.
3. Know how natural draft is produced
4. Know how mechanical draft is produced

Aids:

1. Transparency of natural draft system, 7-C-2-1
2. Transparency of forced draft system, 7-C-2-2
3. Transparency of induced draft system, 7-C-2-3
4. Transparency of combination forced and induced draft system, 7-C-2-4
5. Overhead projector

Procedure:

1. With the use of the transparency, discuss the natural draft system.
2. With the use of the transparency, discuss the forced draft system.
3. With the use of the transparency, discuss the induced draft system.
4. Discuss the reasons why mechanical draft is used.
5. Discuss the factors that a chimney or stack play in producing draft. Discuss its limitations.
6. Discuss how mechanical and natural draft is controlled in the boiler.

Summarize: Discuss natural and mechanical draft, how it is produced, controlled, and effects in the boiler.

Testing:

1. How do you get natural draft and how is it controlled?
2. How do you get mechanical draft and how is it controlled?
3. What is the difference between force and induced draft?
4. What effect does the height of the stack or chimney have on draft?
5. What are some of the ways in which draft can be controlled?

Assignment: Complete Assignment VII-C-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the basic principles of combustion.
2. Know the basic combustion equations.

Aids:

1. Transparency 8-A-1-1, Combustion Equations.
2. Overhead projector

Procedure:

1. Explain the chemical composition of the commercial fuels: nitrogen, oxygen, carbon, sulphur, and hydrogen.
2. Explain the composition of air: nitrogen, oxygen, inert gasses, carbon dioxide, and water vapor.
3. Show with the use of chemical equations how oxygen in the air combines with carbon, hydrogen, and sulphur in the fuel.
4. Explain what the end products of combustion are and how they can affect our environment.

Summarize: Show and explain each equation:

$C+O_2 \rightarrow CO_2 + Heat$

$2C+O2 \rightarrow 2CO+Heat$

$2CO+O_2 \rightarrow 2CO_2 + Heat$

$2H_2+O_2 \rightarrow 2H_2O+Heat$

$S+O_2 \rightarrow SO_2 + Heat$

Testing:

1. What is combustion?
2. What does air contain?
3. What elements do we find in a commercial fuel?

Assignment: Complete Assignment VIII-A-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will:

1. Be able to define the types of combustion.
2. Know why it is necessary to be able to control the combustion process.

Aids: Transparencies 8-B-1-1, 8-B-1-2, 8-B-1-3, 8-B-1-4
Overhead projector

Procedure:

1. Explain what is meant by:
   a. primary air
   b. secondary air
   c. excess air
2. With transparency 8-B-1-1, show primary air damper: trace air flow to fan and around cup to air nozzle.
3. With transparency 8-B-1-2, show primary air damper and secondary air damper. Explain how they work together.
4. With transparency 8-B-1-3, show primary air and secondary air on combination gas and oil burner.
5. With transparency 8-B-1-4, show primary air and secondary air in conjunction with pulverized coal.
6. Discuss: perfect, complete, and incomplete combustion.
7. Discuss air pollution code and how it will affect the operator of residual fuel oil equipment.

Summarize:

1. Perfect, complete and incomplete combustion
2. Primary, secondary, excess air

Testing:

1. Why can't we achieve perfect combustion in a boiler?
2. What does primary air control?
3. What does secondary air control?
4. What are the results of using more excess air than is needed?

Assignment: Complete Assignment VIII-B-1 in Related Science Manual.

Objectives: Upon completion of the lesson, the student will:

1. Know the combustion process.
2. Know what is needed in order to arrive at complete combustion.

Aids: Transparencies 8-A-1-1, 8-A-1-2
Overhead projector

Procedure:

1. Use transparencies 8-A-1-1 and 8-A-1-2 to review chemical theory of combustion.
2. Define:
   a. primary air
   b. secondary air
   c. excess air
   d. perfect combustion
   e. complete combustion
   f. incomplete combustion
3. Explain M-A-T-T in detail
   a. Explain what is meant by ratio of air and fuel and how it must vary during changes in firing rate.
   b. Explain why it is important to bring air and oil in intimate contact with each other
   c. Explain why combustion must be completed in combustion chamber.
4. Discuss composition of air briefly and then lay ground work for math unit on pounds of air per pound of fuel.

Summarize: Review M-A-T-T (Mixture, Atomization, Temperature, and Time)

Testing: Question students about definitions of terms discussed.

Assignment: Complete Assignment VIII-C-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Understand the formula for finding the theoretical amounts of air needed per pound of fuel.
2. Be able to find the theoretical pounds of air required per pound of fuel.
3. Be able to find the theoretical pounds of oxygen required per pound of fue..

Aids: Blackboard

Procedure:

1. Discuss the composition of air.
2. Explain what is meant by ultimate analysis.
3. Explain the formula for finding the theoretical amounts of air needed.
4. Explain the need for 15 to20% excess air for complete combustion.
5. Explain NO–CASH
6. Put sample problem on board and solve for:
   a. theoretical amount of air/# of fuel.
   b. theoretical amount of oxygen/# of fuel.
   c. Using 20% excess air, find actual air required.
   d. Using 20% excess air, find actual oxygen required.

Summarize:

1. NO–CASH
2. Ultimate analysis
3. Formula

Testing: Have students do sample problems.

Assignment: Complete Assignment VIII-C-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be familiar with the mechanical atomizing burner.
2. Know the parts of the burner.
3. Know the operation of the burner.

Aids: Transparency of mechanical atomizing burner, 9-A-1-2
Overhead projector

Procedure:

1. Identify parts, describe, and explain purpose of each.
2. Show flow of oil through burner.
3. Show air flow.
4. Discuss atomizing of fuel oil.

Summarize: Discuss the mechanical atomizing burner; explain the purpose of the burner; and identify and explain the purpose of the burner parts.

Testing:

1. How does the atomization of fuel oil take place?
2. Name the parts in a mechanical atomizing burner.
3. How is oil to the burner nozzle controlled?

Assignment: Complete Assignment IX-A-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose of an air atomizing burner.
2. Know the parts of the air atomizing burner.
3. Know the operation of the air atomizing burner.

Aids: Transparency of air atomizing burner, 9-A-2-1
Overhead projector

Procedure:

1. With the use of overhead projector and transparency, identify and explain purpose of burner parts.
2. Explain fuel oil flow through burner.
3. Explain primary and secondary air supply. How is the air controlled?
4. Explain purpose of gas pilot and how ignition occurs.

Summarize: Discuss air atomizing burner; explain purpose of burner; and identify and explain the purpose of parts.

Testing:

1. What do you think would happen if there was a lack of primary air?
2. What do you think would happen if there is a lack of secondary air?
3. What causes the oil to become atomized? Where does this happen in the burner?

Assignment: Complete Assignment IX-A-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Understand the purpose of the rotary cup oil burner.
2. Know the parts of the rotary cup oil burner.
3. Know the operation of the rotary cup oil burner.

Aids: Transparency of rotary cup burner, 9-A-3-1
Overhead projector

Procedure:

1. Describe burner.
2. Identify burner parts.
3. Discuss purpose of burner parts.
4. Explain oil flow and atomization.
5. Explain primary air, how it occurs, and its purpose.
6. Explain secondary air and show how it occurs.

Summarize:

1. Discuss the purpose of the rotary cup oil burner.
2. Identify and explain purpose of burner parts.
3. Discuss the operation of the burner.

Testing:

1. Why is the rotary cup oil burner popular in industrial plants?
2. Can the burner fire at different firing rates? Explain.
3. How often does the burner have to be cleaned?
4. Name and explain the purpose of the burner parts.

Assignment: Complete Assignment IX-A-3 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the low-pressure gas burner system.
2. Know the high-pressure gas burner system.
3. Know the color code for gas lines.
4. Know and understand the controls in the low-and high-pressure gas system.

Aids: Transparency of low-pressure gas burner system, 9-B-1-1
Transparency of high-pressure gas burner system, 9-B-1-2
Overhead projector

Procedure:

1. With the use of the overhead projector, show the low-pressure gas burner system. Identify the parts in the system and explain the purpose of each.
2. With the use of the overhead projector, show the high-pressure gas burner system. Identify the parts in the system and explain the purpose of each.
3. Discuss the reason for the color coding of gas pipe lines.
4. Discuss where gas and air mix together in both the high-and low-pressure gas burners.
5. Discuss the purpose of the venturi tube.
6. Discuss the purpose of the automatic shutoff valve.

Summarize:

1. Discuss the high-and low-pressure gas burner system.
2. Describe the parts found in the system and their function.
3. Discuss the operation of the gas burner systems.

Testing:

1. What is the difference between the high-and low-pressure gas systems? Explain.
2. Explain the reason for color coding the gas lines.
3. What is the purpose of the pilot line?
4. What is the purpose of the vaporstat?
5. What is the purpose of the gas pressure regulating valve in the low-pressure gas system? In the high-pressure gas system?
6. What is the purpose of the manual reset valve in low-pressure system?

Assignment: Complete Assignment IX-B-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose of a combination burner.
2. Be able to identify a combination burner.

Aids: Transparencies of combination gas-oil burner, 9-C-1-1 and 9-C-1-2
Overhead projector.

Procedure:

1. Explain the purpose of combination gas-oil burners.
2. Explain the advantages:
   a. Flexible (use fuel that is cheapest)
   b. Standby fuel
   c. Air pollution
3. Show transparencies and explain how gas and oil reach burner throat. Identify all parts.

Summarize:

1. Review transparency
2. Explain purpose of combination burner.

Testing:

1. Do you think that a combination gas-oil burner has any advantages over a straight gas or oil burner?
2. How can you identify an oil-gas burner?

Assignment: Complete Assignment IX-C-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know what is meant by refrigeration.
2. Understand the three basic factors involved in refrigeration.
3. Know the part heat plays in refrigeration.

Aids: Blackboard

Procedure:

1. Define heat and energy.
2. Explain kinetic energy.
3. Explain potential energy.
4. Tie in heat and kinetic energy.
5. Define:
   a. B.t.u.
   b. latent heat
   c. sensible heat
   d. latent heat of fusion
   e. latent heat of evaporation
6. Explain theree basic factors involved in refrigeration:
   a. heat exchange
   b. control of pressure
   c. gas-liquid relationship

Note: Very basic discussion – will be covered in detail as the student becomes more involved in the refrigeration program.

Summarize:

1. Explain the close relationship of the heating and cooling process.
2. Explain how the cooling effect is achieved by heat being absorbed by a refrigerant causing it to boil.

Testing: Question students, i.e., terminology.

Assignment: Complete Assignment X-A-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will understand the theory of a compression system.

Aids: Blackboard

Procedure:

1. Discuss the six basic laws of refrigeration:
   a. Fluid absorbs heat when changing from a liquid to a gaseous state.
   b. Fluid gives up heat when changing from gaseous to a liquid state.
   c. If pressure is constant there is no temperature change during change in state.
   d. If pressure increases, temperature will increase and temperature will vary directly with the pressure.
   e. Heat flows from a warm body to a colder body.
   f. Energy is convertible: i.e., heat to mechanical, mechanical to heat, etc.
2. Explain why it must be a closed system.
3. Explain the four basic steps in the refrigeration cycle.

Summarize: Explain how a controlled amount of refrigerant at a predetermined pressure will absorb heat in a low-pressure zone (evaporator) and give up its heat in high-pressure zone (condenser).

Testing:

1. What are the four basic steps in the refrigerant cycle?
2. Where is heat absorbed in the cycle?
3. Where is heat given up in the cycle?

Assignment: Complete Assignment X-B-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be able to describe a compression cycle.
2. Be able to tell where the system divides into a high-and low-pressure side.
3. Know the behavior of gases and liquids in the compression cycle.

Aids: Transparencies 10-B-2-1, and 10-B-2-2
Overhead projector

Procedure:

1. Using transparency 10-B-2-1, explain:
   a. the high-pressure side.
   b. the low-pressure side.
   c. where in the system high-pressure liquid changes to low-pressure liquid.
   d. where in the system low-pressure vapor changes to high-pressure gas.
2. Explain the five steps in compression cycle and function played by:
   a. evaporator
   b. compressor
   c. condenser
   d. receiver
   e. metering device
3. Using transparency 10-B-2-2, explain:
   a. behavior of gases and liquids in cycle.
   b. the temperature-pressure relationship.
   c. at which point in cycle saturated vapor first becomes superheated vapor.

Summarize: Trace the basic compression cycle.

Testing: What is the function of the following:

1. evaporator
2. compressor
3. condenser
4. receiver
5. metering device

Assignment: Complete Assignment X-B-2 in Related Science Manual.

Objective: Upon completion of this lesson, the student will understand the basic principles of the absorption refrigeration system.

Aids:
1. Blackboard
2. Transparency of system, 10-C-1-1
3. Overhead projector

Procedure:
1. Use transparency, or sketch basic components of absorption system on board.
2. Explain difference between mechanical and non-mechanical refrigeration systems.
3. Discuss the advantages of the absorption system over the mechanical type system.
4. Explain the difference between the refrigerant and the absorbent.

Summarize: Discuss the theory of operation.

Testing:
1. What do we mean by the term non-mechanical refrigeration?
2. What must the absorbent be capable of doing?
3. Why is ammonia and water used together in an absorption refrigeration system?
4. Why is the absorption system noted for its quiet operation?
5. For what application can the absorption refrigeration system be used?

Assignment: Complete Assignment X-C-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the basic absorption refrigeration cycle.
2. Know the purpose of the components in the cycle.
3. Know how the cycle operates.

Aid: Blackboard

Procedure:

1. Using a transparency or the blackboard, discuss the absorption refrigeration cycle.
2. Identify and show the location of all components in the system.
3. Discuss the purpose of each component in system.

Summarize: Discuss and review the refrigeration absorption cycle including all component parts.

Testing:

1. Describe the path the refrigerant makes through the system.
2. Describe the path the absorbant makes through the system.
3. Name the parts of the absorption system.

Assignment: Complete Assignment X-C-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Understand the basic principles of the steam jet system.
2. Understand the steam jet refrigeration system cycle.
3. Know the purpose of the components in the steam jet system.

Aids: Blackboard

Transparency of steam jet system, 10-D-1-1

Overhead projector

Procedure:

1. Using the transparency, explain the basic steam jet system.
2. Locate and identify components in the system and explain their purpose.
3. Explain the advantages of using the steam jet system and where it is used.
4. Explain how the pressure in the flash tank is maintained and how the return water is refrigerated.
5. Explain the purpose of the condenser.

Summarize: Discuss the steam jet refrigeration system – its operation, cycle, components, and application.

Testing:

1. What will be the effect of not having enough steam on the system?
2. Why can't the system operate at temperatures below 32°F.?
3. What is the purpose of the condensing water?

Assignment: Complete Assignment X-D-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the difference between the Direct and Indirect Refrigeration systems.
2. Be familiar with the application of each system.
3. Be familiar with the secondary refrigerants.

Aids: Blackboard

Transparency of Direct and Indirect Refrigeration systems, 10-E-1-1, 10-E-1-2, and 10-E-1-3

Overhead projector

Procedure:

1. Using overhead projector or board, explain the difference between the Direct and Indirect Refrigeration systems.
2. Identify and show the location of the secondary refrigerant cycle.
3. Discuss the secondary refrigerant – the different types and their uses.
4. Discuss the reason for using Direct and Indirect Refrigeration systems.

Summarize:

1. Discuss the Direct and Indirect Refrigeration systems – their differences, uses, and applications.
2. Discuss the types of secondary refrigerants including the cycle.

Testing:

1. Why are there Indirect Refrigeration systems?
2. Where can an Indirect Refrigeration system be used?

Assignment: Complete Assignment X-E-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Recognize the types of compressors.
2. Know the purpose of compressors in the Refrigeration Cycle.

Aids: Transparencies 11-A-1-1, and 11-A-1-2

Overhead projector

Procedure:

1. Using transparency 11-A-1-1, explain the suction stroke and what happens in the suction cycle.
2. Using transparency 11-A-1-2, explain the compression or discharge cycle.
3. Explain temperature-pressure relationship, i.e., saturated vapor and superheated vapor.
4. Explain parts of compressor and the function of each.

Summarize: Review one complete revolution or cycle.

Testing:

1. What are the three types of compressors?
2. What are the positions of valves during suction stroke?
3. What are the positions of valves during compression stroke?

Assignment: Complete Assignment XI-A-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose of a condenser.
2. Know the different types of condensers.
3. Understand the operation of the different types of condensers.

Aids: Transparencies of Condensers, 11-B-1-1, 11 B-1-2, 11-B-1-3, and 11-B-1-4
Overhead projector

Procedure:

1. Explain the location and purpose of the condenser.
2. Describe the three main types of condensers.
   a. air
   b. water
   c. evaporative
3. Using transparencies, explain the operation of each type.
4. Discuss the factors that determine the type of condenser to be used.

Summarize:

1. Discuss the location and purpose of condensers in a refrigeration system.
2. Review the different types of condensers and their operation.

Testing:

1. Why is a condenser needed in a refrigeration system?
2. Why are there different types of condensers?
3. What factors determine the type of condensers used in the system?

Assignment: Complete Assignemnt XI-B-1 in Related Science Manual.

Objectives: *Upon completion of this lesson, the student will:*

1. Know the purpose of evaporators
2. Be able to identify the types of evaporators.

Aids Transparencies, 11-C-1-1, 11-C-1-2, 11-C-1-3, 11-C-1-4, 11-C-1-5
Overhead projector

Procedure:

1. Using transparency 11-C-1-1, explain the flooded-type evaporator system.
2. Discuss the action of the refrigerant.
3. Discuss advantages and disadvantages.
4. Using transparency 11-C-1-2, explain the dry expansion system.
5. Discuss action of the refrigerant.
6. Discuss how refrigerant is controlled.
7. Discuss why best efficiency is achieved at peak or heavy loads.
8. Using transparencies 11-C-1-3, 11-C-1-4, and 11-C-1-5, show the three types of dry expansion evaporators.

Summarize:

1. Two basic systems: flooded and dry expansion.
2. Advantages and disadvantages of each system.

Testing:

1. What is the action of refrigerant in evaporator?
2. What controls the amount of refrigerant in each system?

Assignment: Complete Assignment XI-C-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose of a metering device in a refrigeration system.
2. Be able to identify the various types of metering devices.

Aids: Transparencies, 11-D-1-1, 11-D-1-2, 11-D-1-3, 11-D-1-4, 11-D-1-5
Overhead projector

Procedure:

1. Explain the function of metering devices.
2. List the three basic types.
3. Using transparency 11-D-1-1, explain the operating principle of hand-operated expansion valve.
4. Using transparency 11-D-1-2, discuss the parts of the automatic expansion valve and how it operates.
5. Using transparency 11-D-1-3, discuss the low-pressure float-valve location and operation and the type of system it is found on.
6. Using transparency 11-D-1-4, discuss the high-pressure float-valve location and operation and the type of system it is found on.
7. Using transparency 11-D-1-5, discuss the capillary tube location and operation and the importance of design.

Summarize: Function of metering devices – three basic types.

Testing: Ask students to discuss: (1) operation of hand expansion valves, (2) operation of automatic expansion valves, and (3) the function of any metering device.

Assignment: Complete Assignment XI-D-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the location of the generator in the absorption system.
2. Know the purpose and function of a generator.
3. Be familiar with the construction and types of generators.

Aids: Transparencies 11-E-1-1 and 11-E-1-2
Overhead projector.

Procedure:

1. Using transparency 11-E-1-1, discuss purpose of generator and its location in the system.
2. Discuss strong solution and weak solution.
3. Using transparency 11-E-1-2, trace flow of weak and strong solution. Show flow of heating medium.
4. Briefly discuss construction and design of a generator.

Summarize: Review: location, purpose, construction, design, and operation of generator in the absorption refrigeration system.

Testing:

1. What effect would there be on the system if the heating medium to the generator were lost? Explain.
2. What types of heating medium are used in the generator?
3. How does the weak solution in the generator get to the absorber?

Assignment: Complete Assignment XI-E-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the location of the absorber.
2. Know the function and operation of an absorber.
3. Be familiar with the construction and types of absorbers.

Aids: Transparency 11-F-1-1
Overhead projector

Procedure:

1. Using transparency 11-F-1-1, discuss the location of the absorber in the system.
2. Discuss the purpose and operation of the absorber.
3. Discuss the construction and types of absorbers.
4. Explain the effect of weak solution of absorbent coming in contact with refrigerant vapor.
5. Explain and discuss purpose of cooling water in absorber.

Summarize: Review location and purpose of absorber; then discuss types and operation.

Testing:

1. What substances come together in the absorber and what is the effect on each other?
2. How is the capacity of the system increased?

Assignment: Complete Assignment XI-F-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know how a solenoid operates.
2. Know where and why they are used in the refrigeration system.
3. Know the two basic types of solenoid valves and where they are used.

Aids: Transparencies 11-G-1-1, 11-G-1-2, 11-G-1-3
Overhead projector

Procedure:

1. Discuss the two basic types of solenoid valves.
2. Using transparency 11-G-1-1, discuss the parts and position of the valve and plunger de-energized.
3. Using transparency 11-G-1-2, discuss the operation and flow through valve when energized.
4. Using transparency 11-G-1-3, discuss the parts of the valve, and the operation of the valve when the solenoid is energized.
5. Discuss where the valves of each type are used.

Summarize: Two basic types of solenoid valves and how they work.

Testing: Have student describe the operation of pilot-operated valves.

Assignment: Complete Assignment XI-G-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose of suction-line regulators.
2. Know how suction-line regulators work.
3. Know the application of suction-line regulators.

Aids: Transparencies 11-G-2-1 and 11-G-2-2
Overhead projector

Procedure:

1. Discuss the two types of suction-line regulators.
2. Using transparency 11-G-2-1, explain:
   a. location of suction-line regulators
   b. function
   c. reason needed
   d. types
3. Using transparency 11-G-2-2, explain:
   a. location of evaporator-pressure regulator
   b. function
   c. reasons needed

Summarize: Review the two types of suction-line regulators and where each is found in the system.

Testing:

1. When would you recommend a suction-line regulator (S.P.R.) valve?
2. Can you use an evaporator-pressure regulator (E.P.R.) valve on any system regardless of metering device?

Assignment: Complete Assignment XI-G-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Identify and know the location of dryers in the system.
2. Know the purpose of the dryer.
3. Know the different types of dryers.

Aids: Blackboard
Model of dryer

Procedure:

1. Explain the purpose of the dryer.
2. Identify and explain the reason for its location in the system.
3. Explain the two types of dryers.
4. Describe the material used in the dryer and how it removes the moisture from the system.

Summarize: Purpose, location, types, and operation of dryer in the system.

Testing:

1. What would be the effect of not using a dryer in the system?
2. What determines the type of dryer used in the system?

Assignment: Complete Assignment XI-H-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be able to identify and locate the filter and strainer.
2. Know the purpose of a filter and strainer.
3. Be familar with the design and construction of filters and strainers.

Aids: Blackboard

Model of filters and strainers

Procedure:

1. Explain purpose and location of strainers and filters.
2. Discuss condition of contamination and foreign matter in the system.
3. Explain the cause of contamination.
4. Using models, discuss construction of filter and strainer.

Summarize: Purpose, location, design, and operation of filters and strainers.

Testing: Why do you think its a good idea to install filters and strainers in a refrigeration system?

Assignment: Complete Assignment XI-H-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose of a liquid flow indicator.
2. Know the location of a liquid flow indicator.

Aids: Blackboard

Models of flow indicator

Procedure:

1. Explain the purpose of the indicator.
2. Discuss the location of the indicator.
3. Explain advantages of using an indicator.
4. Discuss method of attaching to liquid line.

Summarize: Purpose, location, and operation of liquid flow indicator.

Testing:

1. Can the system operate without liquid flow indicator?
2. What advantage is there in using a liquid flow indicator?

Assignment: Complete Assignment XI-H-3 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be familiar with spray ponds.
2. Understand the theory of operation of a spray pond.

Aids: Transparency 12-A-1-1

Overhead projector

Procedure:

1. Explain the purpose of spray ponds.
2. Discuss the two possible locations for a spray pond.
3. Using transparency 12-A-1-1, explain the theory of spray pond operation.
4. Describe piping and nozzles.
5. Discuss the pressure and temperatures in the water recirculating system.

Summarize: Purpose, location, and operation of spray ponds.

Testing:

1. What is the purpose of a spray pond?
2. Why are nozzles required?
3. How is the water cooled?

Assignment: Complete Assignment XII-A-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be familiar with natural and mechanical cooling towers.
2. Understand the theory of operation of cooling towers.

Aids: Transparency 12-B-1

Overhead projector

Procedure:

1. Explain the purpose of cooling towers.
2. Explain the difference between spray ponds and cooling towers.
3. Discuss different types of cooling towers.
4. Explain the operation of each type.
5. Discuss the method of heat transfer in a cooling tower.

Summarize: Location, purpose, types, and operation of cooling towers.

Testing:

1. Why is water recirculated?
2. Explain what effect relative humidity has on cooling the water.

Assignment: Complete Assignment XII-B-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know why cooling water is treated.
2. Know how to treat cooling water.

Aid: Blackboard

Procedure:

1. Explain water hardness, pH factor, algae, etc.
2. Discuss the conditions that are caused by impurities in the cooling water.
3. Explain external treatment and internal treatment.

Summarize: Why is cooling water necessary and how is it treated?

Testing:

1. What is the purpose of the cooling water treatment?
2. What are two ways in which this is done?

Assignment: Complete Assignment XII-C-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose of a ventilating system.
2. Know the parts of a ventilating system and their function.

Aids:

1. Classroom exhaust grills
2. Nesbitt unit heater
3. Classroom exhaust fan
4. Toilet exhaust fan
5. Kitchen exhaust fan

Procedure:

1. Show student suction at classroom exhaust grill.
2. Show air being brought into room by Nesbitt Heater.
3. Explain to students how classroom and toilet exhaust fans work.
4. Using school fans, take class to see fans in operation.
5. Discuss importance of filters and dampers.
6. Discuss the need for proper filter maintenance.

Summarize:

1. Basic intake-exhaust cycle
2. Importance of controlling toxic and dust-ladened air.

Testing: Ask students why certain minimums have been established by the State, i.e., school ventilating systems, etc.

Assignment: Complete Assignment XIII-A-1 in Related Science Manual

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose of ventilating fans.
2. Know the various types of ventilating fans.
3. Know the various sizes of ventilating fans.

Aid: Blackboard

Procedure:

1. Explain purpose of ventilating system.
2. Using a line drawing, show the complete system on the board.
3. Explain the basic types of fans:
   a. Propeller (low pressure)
   b. Centrifugal (high pressure)
4. Explain how the two basic types of fans work.
5. Explain fan sizes.

Summarize:

1. Purpose of fans
2. Types of fans
3. Sizes of fans

Testing:

1. Do exhaust fans help move air through a house? How?
2. Why do we use fans? How do fans move air?
3. What types are in general use?

Assignment: Complete Assignment XIII-B-1 in Related Science Manual.

Objectives Upon completion of this lesson, the student will:

1. Know the purpose of duct work.
2. Understand duct work design.

Aid: Blackboard

Procedure:

1. Explain the purpose of supply and return ducts in a ventilating system.
2. Explain how duct work is constructed.
3. Discuss friction loss and duct sizing.
4. Explain the method of introducing air into a room.

Summarize: Purpose, location, and design of ducts in ventilating system.

Testing:

1. What determines size of ducts?
2. How is distribution of air controlled into a room?

Assignment: Complete Assignment XIII-C-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know the purpose, location, and types of filters used in ventilating systems.

Aid: Blackboard

Procedure:
1. Explain the purpose of air filters in a ventilating system.
2. Explain the location and types of filters.

Summarize: Purpose, location, and types of filters

Testing:
1. Must you have filters in a ventilating system?
2. What would happen if you had poor filter maintenance?

Assignment: Complete Assignment XIII-D-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know the purpose and location of washers and precipitators.

Aid: Blackboard

Procedure:

1. Explain the purpose of washers and precipitators.
2. Explain the location of washers and precipitators.
3. Explain the operation of washers and precipitators.

Summarize: Purpose, location, and operation of washers and precipitators.

Testing:

1. What is the purpose of washers and precipitators in a system?
2. Discuss their operation.

Assignment: Complete Assignment XIII-E-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will understand what is meant by the term air conditioning.

Aids: Blackboard
Univent in room

Procedure:
1. Ask students to define air conditioning.
2. Explain what is really meant by air conditioning.
3. Explain briefly how this is done.

Summarize: What does air conditioning involve?

Testing: Ask students how they would now define air conditioning.

Assignment: Complete Assignment XIV-A-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will understand the application of domestic, commercial, and industrial refrigeration.

Aids:

1. Trade journals
2. Manufacturers catalogs showing samples of domestic, commercial, and industrial types of equipment.

Procedure:

1. Explain the three basic categories and give examples of each.
2. Show how the refrigeration process remains the same in all three categories.
3. Explain three basic factors:
   a. Exchange of heat
   b. Control of pressure
   c. Liquid-gas relationship
4. Explain the refrigeration process:
   a. Changing liquid to gas
   b. Changing gas back to liquid
5. Briefly discuss what pieces of equipment are used to accomplish this change.

Summarize:

1. Reveiw the refrigeration process (3 factors)
2. How does a liquid change to a gas and back to liquid.

Testing: Have students explain liquid and gas relationship.

Assignment: Complete Assignment XIV-B-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the air conditioning cycle.
2. Know the equipment found in the air conditioning cycle and the purpose it serves.

Aids: Transparency 14-C-1-1

Overhead projector

Procedure:

1. Review what is meant by air conditioning.
2. Using transparency 14-C-1-1,
   a. Discuss the cycle starting at fan.
   b. Trace the cycle through each piece of equipment and explain purpose of equipment in cycle.
3. Discuss the need for:
   a. filter maintenance
   b. careful fan selection and duct layout
   c. good construction and insulation

Summarize:

1. Basic cycle
2. Need for some outside air

Testing:

1. Why is insulation so important to system operation?
2. What is result of poor filter maintenance?

Assignment: Complete Assignment XIV-C-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know the meaning of such electrical terms as:

a. voltage
b. amperage
c. ohm
d. wattage
e. A.C. and D.C.

Aid: Blackboard

Procedure:

1. Explain that electricity is a form of energy and that it can be converted into another form of energy.
2. Explain the term electron flow.
3. Give a definition for:
   a. volts
   b. amps
   c. ohms
4. Explain the term watt as a unit of power.
5. Describe:
   a. direct current
   b. alternating current

Summarize: Define the terms:

a. volt
b. amp
c. ohm
d. watt
e. A.C.
f. D.C.

Testing:

1. What is electricity?
2. Explain what is meant by the terms, volt, amp, and ohm.
3. What is the difference between alternating and direct current?
4. How is electrical power expressed?

Assignment: Complete Assignment XV-A-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will understand the relationship among:

a. current
b. voltage
c. resistance in a D.C. circuit

Aid: Blackboard

Procedure:

1. Explain the relationship between voltage, resistance, and current in a D.C. circuit: OHM'S LAW
2. Explain each equation:
   a. $E = I R$
   b. $I = \frac{E}{R}$
   c. $R = \frac{E}{I}$
3. Using blackboard, show a simple D.C. circuit.
4. Solve sample problems using Ohms Law.

Summarize:

1. Ohm's Law
2. Meaning of E, I, and R
3. Units–ampere, ohm, and volts
4. Equations from Ohm's Law.

Testing:

1. What does Ohm's Law state?
2. How can we use Ohms Law?
3. According to Ohm's Law, what would happen if:
   a. the resistance in a circuit is increased and the voltage is held constant?
   b. the voltage is doubled and the resistance is held constant?

Assignment: Complete Assignment XV-A-2 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know how to solve electrical power problems.

Aid: Blackboard

Procedure:

1. Explain that power is the rate of doing work.
2. Compare terms of mechanical power–ft. lbs per min.–with electrical terms–voltage and amperage.
3. Explain the equation:

   watts = voltage X amperage
4. Develop the equations:

   a. $W = I^2 R$

   b. $W = \frac{E^2}{R}$
5. Show how watts are related to resistance in a circuit using Ohm's Law.
6. Show how to convert watts to kilowatts and how to calculate total power used for a given period of time.

Summarize:

1. Show development of the following equation using:

   $W = E I$, $E = I R$

   $W = \frac{E^2}{R}$ watts = $\frac{\text{voltage}^2}{\text{resistance}}$

   $W = I^2 R$ watts = $\text{amperage}^2 \times \text{resistance}$
2. Show and explain two sample problems for each formula:

   $W = E I$ $W = \frac{E^2}{R}$ $W = I^2 R$

Testing:

1. How many watts are used in each of the following circuits:
   a. 440 volts at 50 amps
   b. 10,000 ohms at 10 amps
   c. 10 ohms at 24 volts
2. What will be the cost of running an appliance for 24 hours if it uses 5.5 amps at 120 volts with a power cost of 3 cents per kw.-hr.

Assignment: Complete Assignment XV-A-3 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know how a simple series circuit is connected.
2. Know how a simple parallel circuit is connected.
3. Know how a series–parallel circuit is connected.

Aid: Blackboard

Procedure:

1. Show a line drawing of a series, parallel, and a series-parallel circuit.
2. Explain how the components of each circuit are connected together.
3. Trace the electron path through each circuit.

Summarize: Explain difference of each circuit.

Testing:

1. Can you think of an application where:
   a. a series circuit would be used?
   b. a parallel circuit would be used?
   c. a series–parallel circuit would be used?
2. What is the basic difference between a series and a parallel circuit?

Assignment: Complete Assignment XV-B-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know how to find the value of the current in a series circuit.
2. Know how to find the total resistance in a series circuit.
3. Know how to find the voltage across any resistor in a series circuit.

Aid: Blackboard

Procedure:

1. With a line drawing, show how the current in a series circuit has only one possible path it can travel.
2. Explain that the current must be the same throughout the circuit.
3. Explain that the current is dependent upon the total resistance in the circuit.
4. Show how to calculate the current in a series circuit.
5. Show that the sum of the voltage across each resistor is equal to the applied voltage.
6. Show examples of:
   a. $R_t = R_1 + R_2 + R_3$
   b. $I = \frac{E}{R_t}$
   c. $E_t = E_1 + E_2 + E_3$

Summarize:

1. Current in a series circuit is the same throughout the circuit.
2. Total resistance is the sum of the resistances in the circuit.
3. The sum of the voltage across each resistor is equal to the applied voltage.

Testing:

1. How do you find the resistance in a series circuit?
2. Is it possible to have more than one value for current in a series circuit? Why?
3. Why should the sum of the voltage across each resistor equal the voltage applied to the circuit?

Assignment: Complete Assignment XV-B-2 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know how to apply Ohm's Law to parallel circuits.

Aid: Blackboard

Procedure:

1. With a line drawing, show a parallel circuit with three branches.
2. Explain that the voltage is the same across each branch.
3. Explain that the current in each branch is dependent only upon the resistance in that branch and the voltage. Then Ohm's Law is: $E = I R$.
4. Compute the current through each branch using 100 volts and the following values for R:

   $R_1 = 5 \qquad R_2 = 10 \qquad R_3 = 30$

5. Explain that the total current in a parallel circuit is equal to the sum of currents in the individual circuits.

   $I_t = I_1 + I_2 + I_3$

6. Show how to find the total resistance in a circuit:

   $$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

   $$\frac{1}{R_t} = \frac{1}{5} + \frac{1}{10} + \frac{1}{30}$$

   $R_t = 3$ Ohms

7. Show how to calculate total power used in a parallel circuit:

   $W_1 = E I_1$

   $W_2 = E I_2$

   $W_3 = E I_3$

   $W_t = E I_t$

Summarize:

1. Voltage is the same across each branch of a circuit.
2. Current is dependent upon the resistance in each branch.
3. Total current is the sum of the current in each branch.
4. The total resistance in a circuit is:

   $$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

5. Power in each branch can be computed from the equation:

   $W = E I$

Testing:

1. Why is the voltage the same across each branch of a parallel circuit?
2. What determines the current in a parallel circuit?
3. How is total current in a circuit calculated?
4. What is the formula for calculating total resistance in a parallel circuit?
5. How is power calculated in each branch circuit? In all the branch circuits?

Assignment: Complete Assignment XV-B-3 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will be able to:

1. Simplify series–parallel circuits.
2. Solve series–parallel circuit problems.

Aid: Blackboard

Procedure:

1. Show a series–parallel circuit and explain how the circuit can be broken up into simpler circuits when solving problems.
2. Show how to solve for the following in a series–parallel circuit:
   a. resistance
   b. current
   c. voltage
   d. power
3. Show sample problems and solve for:
   a. resistance
   b. current
   c. voltage
   d. power

Summarize:

1. Simplifing of series–parallel circuit
2. Solve problems involving series–parallel circuits.

Testing:

1. What steps are necessary in solving problems involving series–parallel circuits.
2. What equations can be used in solving the above problems?

Assignment: Complete Assignment XV-B-4 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know what magnetism is.

Aids: Transparencies 15-C-1-1, 15-C-1-2, 15-C-1-3, and 15-C-1-4
Overhead projector

Procedure:
1. Explain natural magnets.
2. Discuss the magnetic pole.
3. Explain the fundamental Laws of Magnetic Forces.
4. Describe a magnetic field and lines of force.

Summarize: Review natural magnet, magnetic pole, magnetic forces, etc.

Testing: What is magnetism?

Assignment: Complete Assignment XV-C-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the function of a motor.
2. Know the different types of motors.

Aids: Transparencies of motors

Overhead projector

Procedure:

1. Explain the purpose of the electric motor.
2. Explain how steam engines driving line shafts were first used.
3. Explain the use of electric motors and the different type and applications.
4. Brief outline on how a motor works.
5. Discuss the various types of motors and why they are selected.

Summarize: Explain function and use of the different types of motors and briefly outline how a motor works.

Testing: List the types of motors used in domestic refrigeration and explain why they were chosen.

Assignment: Complete Assignment XV-D-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be familiar with single and polyphase motors.
2. Be familiar with motor overload protection.

Aids: Transparency of motor
Overhead projector

Procedure:

1. Using overhead, explain and discuss the types of single-phase motors.
2. Using overhead, explain and discuss the types of polyphase motors.
3. Explain and discuss motor overload protection.

Summarize: Discuss the importance of overload protection on all types of motors.

Testing:

1. What is the difference between a single-phase and a polyphase motor?
2. Why must motors be protected against overheating?

Assignment: Complete Assignment XV-D-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose and location of pressure gages.
2. Know how to read a pressure gage.
3. Know how to select the proper gage for a boiler.

Aids:

1. Transparencies 16-A-1-1 and 16-A-1-2
2. Overhead projector
3. Pressure gage with glass front and back
4. Cut-away of pressure gage
5. Vacuum gage
6. Compound gage

Procedure:

1. Discuss Bourdon and his findings (1849)
2. Explain why gages are needed in boiler plants.
3. Discuss the location and purpose of following:
   a. feedwater gages (suction and discharge)
   b. fuel oil gages (suction and discharge)
   c. control air gages
   d. gas gage
   e. boiler pressure gage
   f. compound gage
4. Using transparencies 16-A-1-1 and 16-A-1-2, explain:
   a. What is meant by the range of a pressure gage.
   b. How gages are calibrated, i.e., pounds per square inch and inches of mercury.
   c. How the value of graduations on the face change with range.
5. Explain why boiler pressure gage must have a certain range.
6. Discuss how steam gages are protected with a siphon and why?
7. Discuss where pressure and vacuum gages are found in air conditioning and refrigeration systems.
8. Discuss how these gages are helpers that keep the operator aware of what is happening and what changes must be made to keep equipment running.

Summarize:

1. Purpose and location of gages.
2. Calibration of gage pressure and vacuum
3. Range of boiler steam gage.
4. Gages are operator's right arm.

Testing:

1. Draw face of pressure gage on board with gage pointer pointing to pressure. Have student read pressure.
2. Follow same procedure using vacuum gage.
3. NOTE: Change range and location of pointer so that it is necessary for student to figure out value of graduations on gage.

Assignment: Complete Assignment XVI-A-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose and location of a manometer.
2. Be able to read a manometer.

Aids:

1. U-tube manometer
2. Inclined U-tube
3. Portable draft gage
4. Transparency 16-B-1-1
5. Overhead projector

Procedure:

1. Review Unit VII-C-1, i.e. definition of draft and need for air in combustion.
2. Using U-tube manometer, demonstrate how it works and how to read it.
3. Using portable draft gage, demonstrate how it works and how to read it.
4. Use transparency 16-B-1-1, discuss parts of diaphragm draft gage and how it works.
5. Discuss static pressure, velocity pressure, and total pressure.

Summarize:

1. Purpose of draft
2. How draft gages are calibrated

Testing: Put sample draft gage readings on board and have class interpret the readings.

Assignment: Complete Assignment XVI-B-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the purpose and types of thermometers in boiler plants.
2. Be able to read a thermometer and interpret its meaning.

Aids:

1. Liquid in glass thermometers
   a. mercury
   b. alcohol
2. Bourdon tube type
   a. liquid-filled
   b. vapor pressure
   c. gas-filled

Procedure:

1. Discuss the importance of logging temperature readings throughout the boiler plant.
2. Discuss how these readings can warn operator of trouble.
3. Using liquid in glass thermometer, explain the parts, how it works, and how to read it.
4. Discuss meniscus of liquid. What causes it? How does it differ in mercury and alcohol thermometers?
5. Using bourdon type thermometers, discuss the theory of operation of each type.

Summarize: Importance of temperature reading, i.e., efficiency and safety

Testing: If normal feed water temperature was 200° F. and your reading dropped to 100° F., what would this indicate to you? Do you feel this would affect your plant in any way?

Assignment: Complete Assignment XVI-C-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know the purpose of thermocouples and how they work.

Aids:

1. Brown Recorder in main boiler room
2. Hand pyrometer
3. Manufacturer's data sheets and catalogs
4. Transparencies 16-D-1-1 and 16-D-1-2
5. Overhead projector
6. Thermocouple

Procedure:

1. Explain what is meant by electromotive force.
2. Explain how the thermocouple works.
3. Explain Brown Recorder.
4. Explain how to use hand pyrometer.

Summarize:

1. Explain how electromotive force is set up due to hot–cold junctions.
2. Explain why the pyrometer can have central location for reading temperatures at many distant points in a plant.

Testing: Question class as to whether an electromotive force will form if hot and cold junctions have the same temperature.

Assignment: Complete Assignment XVI-D-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know the types, purpose, and location of flow meters.

Aids: Blackboard
Boiler room flow meter

Procedure:
1. Explain purpose of flow meters.
2. Explain types of flow meters.
3. Explain location of flow meters.
4. Discuss boiler room flow meter.

Summarize: Stress purpose, types, and location of flow meters.

Testing: Question students about the purpose, place and location of flow meters.

Assignment: Complete Assignment XVI-E-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know the types, purpose, and location of recorders.

Aids: Blackboard
Boiler room recorder

Procedure:
1. Explain purpose of recorders.
2. Explain types of recorders.
3. Explain location of recorders.
4. Discuss boiler room recorder.

Summarize: Stress purpose, types, and location of recorders.

Testing:
1. Where are recorders used?
2. What is the purpose of a recorder?
3. What are some of the variables that recorders are used for?
4. How do recorders help our standard of living?

Assignment: Complete Assignment XVI-F-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know how to take over a shift.
2. Know the routine duties of a boiler operator.

Aid: Blackboard

Procedure:

1. Discuss the State rules and regulations for boiler operation.
2. Discuss the reasons why it is important to take over a shift properly.
3. Discuss the procedure on how to take over a boiler room shift.
4. Discuss the reasons why it is important for the student to know the routine duties of a boiler operator.

Summarize: Review the procedure for taking over a shift and the routine duties of a boiler operator.

Testing:

1. Name six things that the boiler operator must do when taking over a shift.
2. Name six things that the boiler operator is responsible for when he is operating a boiler plant.

Assignment: Complete Assignment XVII-A-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know the routine procedure to start up a boiler plant.
2. Know the routine procedure to shut down a boiler plant.

Aid: Blackboard

Procedure:

1. Discuss the procedure for starting up a boiler plant.
2. Discuss the State rules for boiler inspection.
3. Discuss the importance of being extra careful when starting up a boiler plant.
4. Discuss the procedure for shuting down a boiler plant.
5. Explain the cause of a freezeup in a boiler plant and how to prevent it.
6. Explain and discuss the wet and dry method of laying up a boiler.
7. Discuss the reasons why it is important to clean the boiler when shutting down a plant.

Summarize: Review the procedure to start up and shut down a boiler plant.

Testing:

1. Name some important things that must be done to start up a boiler plant.
2. Name some important things that must be done to shut down a boiler plant.

Assignment: Complete Assignment XVII-A-2 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know how to handle a low-water condition.
2. Know how to prevent a furnace explosion.

Aids:

1. Blackboard
2. Fire eye control
3. Stack switch
4. Low water cut-off control

Procedure:

1. Discuss the danger of a low-water condition in the boiler.
2. Discuss the causes of a low-water condition.
3. Describe the effects to the boiler because of a low-water condition.
4. Explain how to prevent a low water condition.
5. Discuss the importance of the operator being alert at all times.
6. Discuss the procedure for handling a low-water condition.
7. Explain what a furnace explosion is.
8. Discuss the causes of a furnace explosion.
9. Discuss how a furnace explosion is prevented.
10. Explain and briefly discuss the purpose and types of flame failure controls.

Summarize: Review the procedure on handling a low-water condition and preventing a furnace explosion.

Testing:

1. Ask why it is important to prevent a low-water condition in the boiler.
2. How can a furnace explosion be prevented?

Assignment: Complete Assignment XVII-A-3 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will know:

1. How to start up heating plant.
2. What adjustments have to be made.
3. How to operate a heating plant safely.

Aids: Blackboard

School heating system

Procedure:

1. Discuss the feed-water system and the importance of maintaining an adequate supply of feed-water in the boiler.
2. Discuss the fuel system and the preparation to get it ready for service.
3. Discuss the importance of having a clean burner and fuel oil strainers.
4. Discuss the function of the limit and safety controls and how to test them.
5. Discuss the function of the operating controls and the reasons for any adjustments.
6. Discuss the importance of testing the safety controls and checking the water level in the boiler.
7. Discuss and explain the routine procedures of operating the heating plant such as:
   a. blowing down the boiler
   b. cleaning the fuel oil strainers
   c. cleaning the burner daily
   d. checking the various temperatures and pressures

Summarize: Review the procedure for starting up a heating plant.

Testing: What do you think is the first most important thing to check before starting up a heating plant.

Assignment: Complete Assignment XVII-B-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Be familiar with the routine operating procedure of a ventilating system.
2. Know the safety procedures to follow.

Aids: Sample plant log

Blackboard

Procedure:

1. Put sample plant log on board.
2. Discuss importance of taking regular readings.
3. Fill in log using sample temperatures and pressures.
4. After four hours of regular reading, indicate a temperature rise in one section.
5. Question students on the meaning of the temperature rise.
6. Discuss safety procedures and the reasons for safety procedures in the event of fire.

Summarize:

1. Importance of readings
2. Importance of safety procedure

Testing:

1. Temperature drops in South Wing. What does this indicate?
2. Temperature rise in west section of building. What could be wrong?

Assignment: Complete Assignment XVII-C-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know the routine duties for operating an air conditioning system safely and efficiently.

Aid: Blackboard

Procedure:

1. Explain the routine duties of an air conditioning system operator.
2. Stress safe operation.
3. Discuss the compressor, condenser, evaporator, pumps, motors, fans, filters, and lubrication.
4. Explain the location and purpose of safety controls such as high-pressure cut-out, low-temperature cut-out, and low oil cut-out.
5. Explain the purpose and advantages of maintaining an air conditioning plant log.

Summarize: Stress safety and routine operation as a way to more efficient operation.

Testing:

1. What dangers can you think of that might exist in an air conditioning plant?
2. How can we take precautions against those dangers?
3. Does having definite established routines and safety programs help make a plant safer?

Assignment: Complete XVII-D-1 in Related Science Manual.

Objectives: Upon completion of this lesson, the student will:

1. Know how to take over a shift.
2. Know the routine duties of the operator.
3. Know the safety precautions that must be followed.

Aid: Blackboard

Procedure:

1. Explain how to take over a shift and list the procedure to follow.
2. Explain the routine duties of the operator and the reasons he should have to follow them. (Safety and efficiency)
3. Explain the reasons for extreme safety precautions in all refrigeration plants.
4. List all safety precautions and explain why they should be followed. (Protection of life and property)

Summarize: Stress the importance of following the correct safety and operating procedures in a refrigeration plant.

Testing:

1. In what way do you consider a refrigeration plant dangerous?
2. What could be the result if a liquid refrigerant line was broken?
3. How can we improve the safety and efficient operation of a refrigeration plant?

Assignment: Complete Assignment XVII-E-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know the routine service and maintenance required in a boiler plant.

Aids: Blackboard

Manufacturer's data sheets

Procedure:

1. Explain how preventive maintenance saves dollars and jobs.
2. Discuss the need for a written schedule to be followed. Don't rely on memory.
3. Discuss the danger of over lubrication as well as not enough lubrication.

Summarize: Importance of a regular schedule of maintenance

Testing: How often do you have your car serviced? What is done to it? When is it serviced? Isn't it then logical to inspect and service boiler plant equipment on a regular schedule?

Assignment: Complete Assignment XVIII-A-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will know the procedure to follow when the boiler is being cleaned and getting it ready for inspection.

Aid: Pictures of boiler failures from insurance companies.

Procedure:

1. Explain state law, i.e., inspection, boiler certificate, and fines.
2. Explain danger of vacuum, reasons for tagging out valves, and danger of leaving bottom blowdown open.
3. Discuss use of proper lights in steam and water side of boiler.
4. Discuss danger of oil in steam and water side.

Summarize: State law

Safety precautions

Testing: Why do you think it necessary to have boilers inspected annually?

Assignment: Complete Assignment XVIII-A-2 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be familiar with the service and maintenance of a heating plant.

Aid: *A.S.M.E. Code*, Section 6

Procedure:

1. Explain how a heating plant requires the same careful treatment that a high-pressure plant gets.
2. Heating boilers can blow up, so all controls and safety devices require careful testing and maintenance.
3. Explain what causes boiler explosions.

Summarize: All equipment requires proper care for safe and efficient operation.

Testing:

1. What is a boiler explosion?
2. What is a furnace explosion?
3. How do they differ?

Assignment: Complete Assignment XVIII-B-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be familiar with some of the routine service and maintenance required in a ventilating system.

Aids: Classroom Univent

Classroom exhaust grill

Procedure:

1. Put paper on classroom exhaust grill and show suction.
2. Open classroom unit heater and point out outside and inside filters.
3. Show action of outlet-inlet damper.
4. Explain action of univent in winter, i.e., bringing in tempered fresh air.
5. Remove filters; show results.
6. Block filters to simulate dirty filters; show results.

Summarize: Importance of all system components operating properly.

Testing:

1. What was the result of removing filters?
2. What happened when filter was blocked as if it was dirty?

Assignment: Complete Assignment XVIII-C-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be familiar with condenser maintenance and service.

Aid: Blackboard

Procedure:

1. Explain how foreign materials in the condenser affect the system.
2. Explain the purpose of water treatment.
3. Explain how water treatment is done.
4. Explain the dangers of a condenser being located outside.
5. Explain the causes of high head-pressure and temperature.
6. Explain how to chemically and mechanically clean a condenser.

Summarize: Explain and discuss the operation, maintenance, and servicing of the condenser.

Testing:

1. What effect does a dirty condenser have on the system?
2. How does a condenser get dirty?

Assignment: Complete Assignment XVIII-D-1 in Related Science Manual.

Objective: Upon completion of this lesson, the student will be familiar with the service and maintenance of an evaporator.

Aid: Blackboard

Procedure:

1. Explain the importance of correct pressure-drop in evaporators.
2. Explain how refrigerant vapor is superheated and how this prevents liquid slugging at the compressor.
3. Explain air flow and velocity over coils.
4. Explain internal and external fouling of the evaporator.

Summarize: Explain and discuss the operation of the evaporator.

Testing: What do you think would be the effects of a poorly designed or fouled evaporator?

Assignment: Complete Assignment XVIII-D-2 in Related Science.

Objective: Upon completion of this lesson, the student will be familiar with the maintenance and service of compressors.

Aid: Blackboard

Procedure:

1. Explain the need for proper preventive maintenance and servicing of compressors.
2. Explain the reasons for correct lubrication.
3. Explain the harmful effects of poor lubrication.
4. Explain what effect moisture has on lube oil and windings of a hermetic type compressor.
5. Explain why the jacket cooling water must be free of impurities.
6. Discuss reciprocating valve maintenance.

Summarize: Explain and discuss the maintenance and service of compressors.

Testing: What is the purpose of a compressor maintenance schedule?

Assignment: Complete Assignment XVIII-D-3 in Related Science Manual.